Update to Site Conceptual Model and Summary of Remedial Decision Basis Chevron Cincinnati Facility

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Preamble

The following executive summary memorandum is a continuation of the "living" remedy philosophy developed in the Conceptual Remedy Report. In this memo, we provide updates to site understanding that have influenced the remedial goals and decisions. We then review the basis for those updated remedial decisions and provide our best estimates for remedial targets at specific times and locations across the affected areas.

It is important to recognize that as of the date of this memorandum (June 30, 2005), many facets of the more recent updates to the Site Conceptual Model (SCM) are based on extending limited data. Data gaps will continually be addressed as they are identified. It is fully expected that updates and refinements to all critical estimates will occur as additional information is gathered. For instance, we believe there are strong field indications for shorter benzene longevity than previously estimated. However, we also recognize that it is based on sparse data collected at one point in time. It is prudent to think that additional data density spaced through time will result in a better understanding of those timeframes and other aspects of the SCM and remedy.

There are also some assumptions stated in the text with respect to future land use plans and the desire by the community to put the site back into safe beneficial use sooner rather than later. These desires have some tie-ins to why some technologies were ruled out, as they require intensive surface access over several years.

In keeping with past interactions with the EPA, the site technical team will continue to keep developments in understanding updated and available. We will review SCM updates in terms of whether they affect remedy decisions and actions, in what specific ways, and whether changes in site actions are warranted. Fundamentally, we are looking for concurrence from the EPA that based on our current understanding and the site circumstances, the proposed final remedy is in keeping with our mutual environmental protection goals. The details of reaching those goals will continue to improve through time and through implementation of the remedial process.

Introduction

As requested by the U.S. Environmental Protection Agency (USEPA) on May 11, 2005, this memo summarizes Chevron's updated understanding regarding plume conditions at the former Gulf Refinery near Hooven, Ohio (Figure 1 & 2, Index Map and Site Area Map). This understanding provides the basis for our proposed conceptual groundwater remedy (submitted July 2003). These updated technical findings and interpretations post-date the Corrective Measures Study (CMS, July 2001), and reflect ongoing improvements in the Site Conceptual Model (SCM). Specific updated findings to be discussed herein include:

1. A diminishment in the estimated longevity of benzene

2. An interpretation that the LNAPL and dissolved-phase plumes are stable under ambient (non-pumping) conditions

3. Improved understanding of the LNAPL plume morphology along the riverbank and north/ central portion of the site

4. An associated concern along the riverbank for stream flow erosion into that LNAPL zone

Further updates to the SCM through time are expected as additional data and insights are acquired through the remedy implementation process. If future SCM updates affect the remedial goals and actions, those will be updated accordingly. This "living" SCM and decision process embraces the expectation that information and knowledge change through time, and a new understanding needs to be considered in context with the remedial decisions.

As a result of past evaluations and updates to the SCM understanding, this memo will summarize the basis for Chevron's selected remedy decisions to date. The decision framework identifies remedy goals, locations at which goals apply, when goals will be achieved, technology comparisons, and field performance measures for the selected remedial strategy. The proposed remedy actions are consistent with the framework developed by Chevron and presented to the EPA in a letter dated March 25, 2005 (Table 1). This memo will specifically address the following remedy items:

1. The decision basis and screening applied to remedy options that resulted in the selected remedies in the Conceptual Remedy Report (CRR; July 2003)

2. An updated explanation of the final remedies selected, including the high-grade LNAPL recovery program and revised considerations for the protection of the Great Miami River (River)

3. An update of point of compliance locations with monitoring protocols

4. Short (one to five years) and longer-term remedy performance monitoring goals and locations

Site Background

This brief synopsis is provided for context and is taken directly from prior facility documents. More extensive discussions of site conditions may be found in the CMS and CRR (2001 & 2003, respectively).

The former refinery, located about 20 miles west of Cincinnati, produced typical fuels and petroleum products during its operations from 1931 to 1986. Its operational footprint is bordered by the Great Miami River to the east, northeast, and southeast, and by the community of Hooven and SR 128 to the west (Figure 2). Except for the facility operations building, other operations structures have been removed.

Over the course of operations, accidental releases to soil and groundwater of primarily gasoline and diesel range fuels occurred, resulting in the presence of light non-aqueous phase liquids (LNAPLs) in the subsurface over approximately a 250-acre footprint (Figure 3). In addition, oily sludges and other solid wastes were disposed of at the facility, and are being considered separately under the soils remedy. The soils remedy is currently being implemented through a massive excavation effort, and the effects of those actions on the groundwater remedy will be considered subsequently.

In 1993, Chevron entered into an Administrative Order on Consent (Consent Order) with the USEPA to perform a Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) and Corrective Measures Study (CMS). The RFI was completed and approved by the USEPA in 2000, and contains additional background beyond that covered herein. With USEPA concurrence, the CMS was divided according to media, with one CMS for soils/sludges and another for groundwater (the Groundwater Corrective Measures Study or GW CMS). The soils/sludges CMS and GW CMS reports were submitted separately to USEPA Region 5.

The GW CMS selected a remedial alternative of “containment.” This was based on an extensive remedial analysis that included evaluating the costs and benefits of a number of technologies. The GW CMS also specified that the selected alternative be “optimized,” which resulted in the Conceptual Groundwater Remedy Report.

Chevron has been involved with remedial activities at this site since 1985. During this time period, impacts have been significantly reduced. Free phase LNAPL migration to the river has been mitigated, several million gallons of free product have been recovered, tens of billions of gallons of groundwater have been treated, community groundwater production wells have been relocated to enhance protectiveness, 270,000 cubic yards of impacted soil materials have been excavated and removed from the facility (additional removal is ongoing), and soil vapor extraction has removed approximately 447,000 pounds of hydrocarbon from beneath Hooven. However, there are remaining issues to be addressed. Residual-phase LNAPL is present along the river, and recent erosion of the riverbank during a River flood event necessitated submittal of a plan for stabilizing the bank to the EPA. Frequent LNAPL occurrence is present in wells on- and off-site in southern areas of the plume, and residual impacts to groundwater remain. Near-term, all sensitive receptors, human and otherwise, need to be protected, and there must be contingencies in place for unforeseen events. Longer-term, the aquifer needs to be restored to its maximum beneficial use.

Updates to Site Understanding

The following subsections summarize the updated understanding of key elements within the SCM. As mentioned, these updates post-date the CMS and directly affect the reasoning for the proposed conceptual groundwater remedy (July 2003).

Plume Morphology Updates

A good understanding of the plume morphology was present at the time of the CMS. However, the recognition of the intimate relationship between this morphology and the management of the plume caused closer evaluations of the plume morphology in the CRR and through ongoing investigations. The form and structure of the LNAPL body has been more closely described through geographic analyses of borings and CPT/ROST geophysical information. This morphology and architecture is then intimately related to chemical partitioning, flux, longevity, risk, and cleanup considerations. Evaluations and mapping of these features have now improved the total understanding in all areas of the facility, lending refinement to the remedial decision analysis (discussed subsequently).

Updates to the Plume Footprint

As more data points have been acquired through time, the LNAPL footprint has expanded geographically as a result. While this may be misinterpreted as plume movement, it is simply a result of a new understanding of the plume distribution, not a new movement into previously pristine areas (plume stability is discussed below). The additional refinements have also led to a slight change in the plume configuration, and further minor refinements are expected as additional data are collected.

The LNAPL plume footprint refinements are based on "LNAPL indicator" evaluations and mapping. Indicators of probable LNAPL occurrence include mixed pieces of field data from boring logs, LIF logs, monitoring wells, and other screening and observational data. Indicators may include PID readings above background, visual staining or sheening, LNAPL in wells, LIF signals above background, and other supporting information. Using these combined indicators, there is now a much clearer picture of the plume footprint and morphology, as expressed through several figures provided here. Figure 3 is the updated LNAPL plume footprint interpretation, and shows two prior interpreted extents that were based on more limited data availability and/or lesser interpretive refinement. Figure 4 shows the interpolated contours of the smear zone thickness throughout the estimated footprint, as derived from boring and LIF geophysical logs. The smear-zone is defined as the portion of the LNAPL plume that is within the aquifer and its historic range of water levels. Significant thinning is observed at the plume periphery, particularly in the down-gradient direction. This is consistent with LNAPL spreading theory, and implies a smaller chemical source mass and low mobility potential in these distal areas.

Update to LNAPL Morphology along River

Since the time of the CMS and CRR reports, a significant number of data points have been collected along the Great Miami River bank along the southern portions of the facility (Figure 5). Further investigations are currently underway, and updates in site and plume understanding are expected as those data are evaluated. These investigations are intended to provide a refined understanding of the LNAPL zone morphology and chemistry near the riverbank, and to assist in designing a protective remedy along the river segment. This update discusses only our preliminary understanding of the riverbank LNAPL morphology and chemistry.

The most informative understanding of the LNAPL morphology has come from the co-mapping of CPT/LIF geophysical information with the recent analytic chemistry results along a line of cross-section paralleling the river (Figure 6, line of section shown in Figure 5). In this section, the LIF intensity is shown in increasing shades of blue, and the geophysical soil characteristics are shown from brown (finer-grained) to yellow (coarser-grained). The figure shows the symbolic analytic results for recent soil and groundwater sampling along the section, as well as the high/low water table range. There are no benzene detections in smear zone soil samples, with TPH in soil detected to a maximum of 1,700 mg/kg in the smear zone (about 1% LNAPL saturation equivalent). The groundwater contains a maximum of 41-ug/l benzene and a maximum of 16,000 ug/l TPH (note that these groundwater samples were collected approximately 30- to 50-ft back from the riverbank). Additional studies currently underway are refining the chemical distribution at the riverbank/aquifer interface. In total, these analytic sample results are consistent with the remainder of the site conceptual model. The benzene is primarily depleted from the LNAPL source, and the saturation of LNAPL near the riverbank interface appears to be small (based on the available results), suggesting a residual condition.

The morphology of the riverbank setting is observed to be a fining-upward depositional environment, consistent with the fluvial setting. The distribution of LNAPL along the riverbank is variable, and there are apparently “clean” zones (like at MW-7) separating zones of LNAPL impacts along the river. Further detail into this morphology and chemistry will allow the design of the final remedy. The given morphology suggests the greatest threat to the river could be caused by river erosional events into the LNAPL zones along the bank. This concern, coupled with the morphology, suggests the potential for a protection approach that tailors an engineered control to the local conditions. This will be evaluated once remaining chemical, gradient, and other information are compiled from the ongoing investigations. A plan for conducting additional investigation along the River was submitted to the EPA in a letter dated June 15, 2005.

Benzene Distribution in LNAPL

The benzene distribution in LNAPL is of interest because it represents the “source” term for partitioning to groundwater and soil vapor. As the source term depletes, there is a corresponding decrease in fluxes in the daughter plumes, with an associated increase in environmental protection.

Benzene was sampled in LNAPL at various pumping well locations to assist with the treatment system operations and meet the NPDES permit requirements (A.D. Little, 1999). While these points are sparse relative to the size of the LNAPL footprint, mapping and interpreting these results presents an interesting snapshot (Figure 7). The data support an interpretation that the benzene concentrations in the LNAPL are depleted on the plume boundaries and remain more persistent in the plume core.

The interpretation of benzene weathering from the “outside-in” is also supported in the vertical dimension. Figure 8 shows a detailed geophysical and analytic sampling log from the PITT test area, located about 40-ft west of MW-40 (from Radian). As seen in this log, TPH remains elevated in concentration throughout the LNAPL vertical interval, but BTEX compounds are depleted at the upper and lower boundaries. Losses at the upper boundary primarily indicate vapor phase losses in the vadose zone. BTEX losses at the lower boundary primarily represent depletion by dissolved-phase processes.

In summary, the expected mechanisms of plume depletion are indicated by the measured and interpreted benzene distribution in the plume. Weathering from the outside-in has several implications to plume management decisions. First, the time to reach the benzene MCL will be sooner at the plume periphery than in the plume core. Second, the LNAPL "source" is apparently stable, as benzene is depleted at the leading boundaries in the southwest quad (other stability indicators are discussed below). In the area of MW-48S, near production well PW-15, one can infer an elevated benzene concentration profile that likely represents the effects of containment pumping in drawing the LNAPL closer to that location from the core area; i.e., a direct indication of what induced LNAPL mobility may be expected to look like.

Benzene Longevity

Benzene is the key compound of concern (COC) at the site emanating from the LNAPL source. Its longevity under ambient conditions is important to the remedy decisions, as each remedy will have some effect on that longevity; the updated understanding is for a significantly lesser longevity than previously estimated. Longevity here refers to the time required for the benzene to partition from the LNAPL source and degrade such that MCLs are achieved throughout various portions of the plume footprint; biogeochemical indicators of biodegradation have been confirmed at the site.

In the CMS, the estimated benzene longevity was approximately 450-years based on numerical modeling performed for the aqueous-phase depletion of benzene from the LNAPL. The calculations were based on detailed parameterization from the partitioning inter-well tracer test work (PITT, presented in URS, 2001 (Duke Environmental Services Report – Draft – Attenuation Zone Task 2, Dissolution if BTEX from LNAPL, February 2001). This modeling showed the expected mechanisms of aqueous-phase depletion with partitioning first occurring from the up-gradient side of the LNAPL plume and from the bottom-upwards (outside-in weathering; Figure 9). This portion of the work holds. However, we have subsequently recognized the importance of volatilization to the net losses of benzene and other volatiles from the subsurface system. Accounting for that facet, the longevity of benzene is more likely on the order of 100 years or less from the time of the original release, as discussed below. Part of the ongoing performance plan is to further demonstrate these mass losses directly through field information, as this updated understanding is based on relatively few data points.

The key field indication that this shorter benzene lifespan is a more accurate estimate is the observed losses of benzene from the plume relative to its initial presence in the fuels at the time of release. The recent interpretive distribution of benzene in the site LNAPL plume is shown in Figure 7 and is the basis for the following observations. First, the average percentage of benzene in LNAPL samples across the site since 1998 is approximately 0.22% (updated from the CRR based on additional data). This is an order of magnitude less than the 3 to 4% benzene fraction expected in leaded gasoline from the 1960s; that the original gasoline released occurred in this general timeframe is based on its alkyl lead character (concentration and makeup; Al Verstuyf; Chevron). Second, benzene concentrations in samples collected from the margin of the LNAPL plume are much lower than samples collected from locations in the central portion of the plume. Benzene remains more concentrated in the plume core areas where the smear zone is thickest, has the greatest remaining mass, and is interior with respect to LNAPL partitioning mechanisms. This relationship suggests that LNAPL weathering and benzene depletion have progressed more rapidly in the thinner, distal portions of the LNAPL plume, as anticipated by the dissolution modeling discussed above. Vapor partitioning also works from the LNAPL interface downward into the LNAPL body (outside-in).

Groundwater flow and dissolved-phase partitioning is relatively well constrained at the site. For the observed weathering and mass loss of benzene to have occurred, another loss mechanism is needed. Vapor profiles and flux measurements at the site indicate that losses in the vapor-phase are that mechanism, and likely account for approximately 75 to 85 % of the observed losses. More details regarding this approximation were provided in the CRR, but irrespective of those, this general finding is supported directly by the field observational information. The focus in further updates to the longevity estimates will be on additional field data collection.

Plume Stability Interpretation

The groundwater CMS implicitly considered the LNAPL and daughter-phase plumes as potentially mobile when the final groundwater remedy options were developed. As a result, the recommended containment option was premised on active hydraulic control of the plume. Subsequent to that time, a more thorough examination of site information suggests that the LNAPL plume would be stable under ambient conditions, as would likewise the daughter-phase plumes after a short period of re-equilibration. This new interpretation of plume stability was carried forward in the Conceptual Groundwater Remedy Report. Stability herein means no geographic movement of the plume footprint that would require a management action, but allowing for local area redistribution within the plume. A key requisite in the Remedy is that this interpretation be confirmed through additional field data collection and interpretation.

The basis for the updated interpretation of stability is premised on several lines of evidence including site-specific observations, theoretical expectations, and other supporting information. When taken individually, these lines of evidence are not fully conclusive. Collectively, the combined weight-of-evidence provides for a compelling stability interpretation. However, it must also be recognized that the overprint of hydraulic containment since the mid-1980s makes definitive confirmation difficult without additional field verification. As in other key technical facets, the site team is still in the proving stages of the remedy decision.

The important lines of evidence that indicate plume stability without active pumping are discussed below. As a related side-note to be discussed subsequently, the Great Miami River is at risk due to erosion and direct contact of the stream waters with the residual and immobile LNAPL on the riverbank. This mechanism is different than hydraulic movement of the LNAPL toward and into the River; this type of hydraulic movement was seen historically in the mid-1980s and precipitated a variety of protective actions to eliminate that mechanism. The indicators of a stable plume include:

1. **<u>The site LNAPL plume is decades old</u>**. The potential timing of the key gasoline release was discussed above (1960s), and a final timestamp for potential releases was 1986 when the refinery stopped all operations. The gradient and hydraulic conductivity toward LNAPL both diminish exponentially through time following a release. Numerical reservoir modeling discussed previously with the EPA suggests that LNAPL movement would stop in less than 10-years following a release. As we are 20-years past all operations and an estimated 40 to 50 years after the significant releases, this indicator suggests that the plume should be stable.

2. **Small LNAPL gradients**. LNAPL movement is initiated by the presence of an LNAPL gradient, directly analogous to groundwater flow; in the absence of a gradient, there will be no flow. The LNAPL gradient at the site is less than 2 x 10^{-3} ft/ft under distal pumping conditions (Figure 10), and would be expected to be smaller still under ambient conditions; this measurement in 1999 was during a drought and worst-case LNAPL conditions. Small LNAPL gradients are generally insufficient to overcome water-wet pore entry pressure resistance at the outer edges of the plume, resulting in immobility.

3. **Small LNAPL transmissivity and conductivity**. The ability of the LNAPL to move through the formation under a gradient is dependent on the transmissivity and conductivity toward that phase. The LNAPL transmissivity values estimated from recovery records and well tests indicate the values are generally 10,000 to as much as 1,000,000-times smaller than groundwater transmissivity values. In addition, the past remedial efforts have produced a decrease in T_n beyond that present before pumping began, acting to further stabilize the plume. These small T_n values indicate a negligible LNAPL mobility potential.

4. **No new LNAPL encroachment**. All available well and boring logs were inspected for the presence or absence of LNAPL in the formation at the time the data points were installed. Then, more recent records were inspected and evaluated to determine whether there were any cases where LNAPL is now present where it was not in the past historical sampling. For the limited number of down-gradient borings that were "clean" on installation, there were no cases of subsequent LNAPL encroachment into those areas.

5. **Residual saturation**. Petrophysical tests on aquifer cores to support past multiphase modeling indicated two-phase (water-oil) LNAPL residual saturation ranges from about 18 to 25%. Testing in the PITT area and other supporting site data indicates that most of the LNAPL plume is present at saturations less than these residual values (immobilized). However, it is important to recognize that two-phase LNAPL residual saturations are greater than three-phase values (water-oil-air) residuals. As the water table drops, LNAPL "reappears" in wells and may locally redistribute during these transient events. It is also important to recognize that field residual values are affected by hysteresis and other factors, and it is possible to have different values (i.e. smaller) as a function of the plume intrusion history at particular locations. Overall, site saturation values appear small relative to the residual saturations measured in the lab.

6. **Relative permeability.** The relative ability for LNAPL to move while above residual saturations in the presence of water is governed by the relative permeability of the specific soil and LNAPL pairs. Site laboratory measurements show an exponential decrease in the ability of LNAPL to move in the presence of water at saturations less than 20 to 25%. This mechanism is reflected in the field in the lower recoverability and transmissivity toward LNAPL today than that present when remedial actions began in the mid-1980s.

7. **Plume Morphology**. As discussed above, the plume is "thick" in the center and thin at the edges. This is the morphology of a stable plume anticipated by the multiphase mechanics discussed in the CRR and derived through prior modeling efforts. A mobile LNAPL body will have a thicker down gradient imprint than observed at the facility.

Since the LNAPL was released before hydraulic containment began, it can be inferred that this morphology is predominantly the result of ambient plume spreading and ultimately stabilization processes.

8. **<u>Benzene Weathering Morphology</u>**. A sister observation to #7, the benzene content of the LNAPL varies as a function of the spatial morphology. Site LNAPL analytic data suggest that benzene has been preferentially depleted from all outer interfaces between the LNAPL phase and other media phases. This outside-in weathering with respect to the LNAPL body indicates the LNAPL plume is stable. If the LNAPL body were moving downstream, then there would be a chemical bias toward benzene replenishment at the leading edge of the plume. These weathering patterns support that the parent LNAPL source material is stable.

9. **<u>Natural Attenuation of the Daughter Plumes</u>**. Site groundwater and vapor data both indicate that natural attenuation processes are active in the subsurface. In the vapor-phase, biogenic, fixed, and hydrocarbon gas profiles directly support attenuation and the absence of a complete pathway to the surface. Dissolved-phase attenuation indicators have also been collected and support that attenuation processes are active in the aquifer (detailed summary in the CRR).

In summary, the weight-of-evidence is for plume stability in all phases (LNAPL & daughter). There are potential obscuring factors, such as pumping history and low interfacial tensions between oil and water. Overall, the majority of important factors indicate that the LNAPL and daughter plumes would be stable under ambient conditions. The performance measures and contingencies discussed subsequently are intended to prove this stability through field demonstrations, and include adequate safety, planning, and contingency actions should other outcomes be found.

Remediation Decision Basis

The CMS considered several potential remedies, many of which were eliminated from the screening process due to inapplicability to the stated remedy goals in that plan. Four potential remedies were then selected for in-depth consideration: 1) Containment; 2) Containment plus soil vapor extraction [SVE]; 3) Containment plus SVE and air sparging [AS], and 4) Containment plus AS and Surfactant Enhanced Aquifer Remediation [SEAR]. Containment was the selected remedy in the CMS based on RCRA screening Guidance, and the proposed implementation of this action was detailed in the CRR.

The following sections will present a review of the basis for the selection of the proposed remedy presented in the CRR. This discussion will be presented on the basis of location within the plume, and timeframes to meet objectives at those locations using various technologies. In essence this is a re-visitation of the CMS decision process, and includes additional clarifications that were not present in the CMS report.

Receptor Protection

The highest priority in the CMS, CRR, and in recent communications with the EPA is the protection of all potential environmental receptors. Of the potential environmental receptors, human health and safety is a paramount concern. The CRR defined a point-of-compliance boundary outside of which no chemical concentrations or migration above regulatory levels would be allowed (Figure 11). Within the POC, environmental risks are either not present, or in some cases are potentially present but can be managed through appropriate building and land-use controls consistent with the land-use goals of the community.

This receptor priority is encompassed in our final remedy matrix provide to the EPA on March 25, 2005, and re-presented herein in Table 1. While existing information indicates that key receptor protections are predominantly met currently, Chevron's goal is to have all pathway protections verified and complete within one year of the execution of the Remedy Agreement.

Other Remedy Goals

Beyond the receptor-based goals above, other goals are recognized in the CRR. While the LNAPL and daughter-phase plumes are expected to be stable, additional engineered remediation actions will add safety factors to that stability. Chevron would like the specified recovery actions to reduce the frequency and magnitude of observed LNAPL in wells at off-site locations, including the residential area of Hooven and the business area in the Southwest Quadrant. In addition, the planned high-grade recovery operations are based on accomplishing similar goals in a portion of the onsite property. Implicitly, these goals and those above recognize an effort to recover LNAPL to the degree practicable that will likely result in longer-term environmental management benefits. Chevron would also like to reduce the benzene longevity more than would be realized under ambient conditions, and do so with priorities in specific site areas, as discussed below.

In addition, a land-use plan was developed in 1997 with a variety of potential options. In 1997 and reconfirmed in 2001, the Community Advisory Panel (CAP) voted for a mixed-use option. During meetings with Chevron, the CAP requested this land-use be implemented within 10 years (by 2011). This land-use included light industrial/commercial in the southern portions of the facility, and open space and recreational uses in the north (Figure 12). Remedial management decisions recognize this desired land-use, and require that the land-use is safe while balancing that the remedial measures do not impede timely development and use.

Spatial Relationships of Remedy Goals

As discussed in the CRR, while the POC forms a continuous boundary line, each key segment has different protection goals, and divided further, different actions are needed to achieve those goals. Each of the conceptual segments is summarized below as taken from the CRR.

Segment A of the POC boundary on the southern border is intended as a boundary beyond which there will be no additional plume movement (Figure 11). While there are no current direct threats from further encroachment, the receptor based goal is to keep groundwater free of chemicals emanating from the site plume so that there is unimpaired and unrestricted use of land and groundwater outside of this boundary. Detailed plume monitoring and confirmation of stability within this POC is the direct action, with contingencies for unexpected outcomes.

Segment B is the western boundary of the POC that represents the point at which the alluvial aquifer pinches out against the bedrock strata that form the hills west of the CCF and underlie the valley alluvial fill. This contact between the alluvium and bedrock strata is documented from outcrops of bedrock west of SR 128, geologic logs of boreholes and monitoring wells at the

CCF, and the results of the seismic refraction survey which delineated the contact between bedrock and alluvial materials under the CCF. Segment B represents a natural hydrologic (no-flow) boundary and requires no active attention to achieve protective conditions outside this segment.

Segment C represents the northern and eastern boundaries of the CCF site that is characterized by groundwater flow from the Great Miami River toward interior portions of the CCF and the hydrocarbon plume. Natural groundwater flow is either perpendicular to the plume margin (north portion of the segment) or is sub parallel to the margin of the plume (east and southeast portion of the segment). Therefore, the margin of the plume is either down gradient or cross gradient to the direction of groundwater flow. These gradient conditions persist regardless of whether the water table is at high or low conditions. Based on groundwater flow modeling and evaluation of the hydraulic gradients and flow directions in the aquifer, dissolved hydrocarbons will not migrate up gradient or cross gradient toward the Great Miami River across Segment C. Therefore, no active mitigation is required along this segment of the POC, but confirmation monitoring is necessary.

The POC segment D running from north-to-south along the Great Miami River is a location of key focus and is intended to protect the river from three types of potential plume discharge: 1) Direct hydraulic movement of LNAPL into the River, as was at one-time occurring in the mid-1980s; 2) LNAPL contact with the river through bank erosion in locations where residual LNAPL is present in soils adjacent to the river bank; 3) Discharge of dissolved-phase mass at levels above Ohio surface water standards. A recent erosional event on the riverbank on this segment highlighted the need for active consideration of this POC segment in the remedial designs. Detailed characterization studies are underway to determine a proposed remedy along this river segment.

The remaining remedy goals are applicable within the interior of the POC (Figure 11). As with the POC segments, not all areas within the POC are equal in terms of either priority or remedy considerations. In the Hooven area, residences are present above the plume, and while past and recent work has indicated that there are no complete risk pathways, the residential setting deserves special attention. In the Southwest Quadrant, businesses are present and additional commercial uses may be anticipated, and are likewise a concern. In the central and northern portions of the site, the land-use plan addresses existing impacts through use and building controls. There is a lower priority for directing actions specifically to these areas, while recognizing that they are still a part of the holistic remedy and further remediation will occur therein. The shading in Figure 11 shows these different regions inside the POC to clarify the intent discussed in the CRR (but was not presented therein).

Time Required to Achieve Goals

The discussion above suggests different life-cycle timeframes for remedial actions are applicable to different segments of the POC boundary and to different geographic sectors inside the POC. The following framing summarizes our preliminary timeframe goals within each of these areas. As discussed in prior sections, our site understanding has grown significantly in the last several years, as has the recognition of data gaps for defining timeframes in the field. The timeframes below represent our best estimates based on the available information on plume longevity, while recognizing that new data/information may cause future updates. The timeframes will be revisited periodically in the future, in order to ensure that progress is being achieved toward the goals. For each of the timeframe goals, achievement will be based on geostatistical results for an area as opposed to single discrete locations to account for natural variability in the system.

1. **<u>POC Segments A through C</u>**. MCLs are currently met, and will continue to be met through the proposed remedy transitions with continued performance verifications and contingencies for additional action (both aspects are discussed subsequently).

2. **<u>POC Segment D</u>**. This segment is critical to protection of the river. The river has been protected through active hydraulic containment since 1985. Recent bank erosion and LNAPL exposure points to the need to accelerate the understanding along this segment and develop a longer-term protection plan. A recent work plan describes ongoing activities in that delineation, and interim shore construction measures are being implemented while a final remedy is designed. Chevron will prepare a final remedy plan for this segment to the EPA following completion of additional investigation and analysis along the riverbank. Implementation of the planned remedy will begin within 90-days of EPA approval, contingent on permitting with the State of Ohio, the Army Corps of Engineers, and other entities controlling the river system. The completion date will depend on construction implementation and other practical considerations such as river stage, safety, and required sequencing.

3. **<u>Areas internal to the POC</u>**. While Chevron's understanding and timing on near-term, receptor-based goals are clear, the timing of longer-term goals within the POC is currently uncertain. Our updated understanding presented previously is premised on sparse data that were collected for reasons other than estimating the timeframes of remedial actions. Further, key components of the proposed remedy (discussed below) are premised on naturally occurring low water table stands "opening" the smear-zone to LNAPL and HSVE recovery actions. Because that remedial optimization has not yet occurred, it is difficult to estimate the long-term effects of the actions without the supporting field data.

   Chevron's remediation philosophy and commitments, however, are clear. For areas within the POC, our focus on accelerating cleanup times will be in Hooven and the Southwest Quad. We expect to see cleanup acceleration in the southern and northern portions of the facility as well. However, the land-use in the northern area is such that accelerating the time to reaching cleanup goals has less short-term benefit with respect to land use plans. Given that our updated understanding has suggested that plume lifespan will be less in offsite plume areas, our remedy is expected to act in concert with these other degradation processes to further reduce chemical lifespan. Our preliminary estimate is that our proposed remedy can achieve cleanup goals beneath Hooven and the Southwest Quad in 30 years or less. However, commitment to a firm and bracketed estimate will depend on remediation and field performance tracking over the next 5 years of implementation. During that time, we expect to see at least one drought event (trigger), and will have a comprehensive set of measurements for the distribution of benzene in LNAPL, leading to a better ability to estimate remedial timeframes. Chevron expects to work with the community and the EPA over the next 5 years of remedy implementation to better define the specifics of cleanup goals and timeframes for areas within the POC.

Remedy Decision Rationale

As detailed in the CRR, the selected remedy includes an engineered action to protect the River (studies underway), focused high-grade pumping to optimize LNAPL recovery and plume stabilization, and HSVE in Hooven during high-grade events to recover benzene and other volatiles. In addition, the mass recovery and high-grade action are expected to enhance the rate of benzene mass losses beyond that which would be present under ambient conditions. This would be caused by increased advective groundwater flow under high-grade pumping, vertical LNAPL redistribution that would enhance the partitioning and decay, and directly through the mass recovered. The following discussion summarizes the basis for this remedy selection.

Given the timeframe and geographic cleanup goals discussed above, the decision process used in the CMS still applies, but with the updates in understanding discussed above. Key updates are that the benzene longevity under ambient conditions is likely much smaller than previously estimated, and that the LNAPL and daughter plumes are likely stable under ambient conditions. The key remedial goal in the CMS was based on the Handbook of Groundwater Protection and Cleanup Policies for RCRA Corrective Action (USEPA, April 2001; EPA530-D-00-001): "EPA expects final remedies to return groundwater to their maximum beneficial use, wherever practicable, within a time frame that is reasonable given the particular circumstances of the facility." The CRR report and other updates herein have refined those details with respect to both timing and location (i.e., the circumstances of the facility).

In the CMS, many technologies were considered for potential application, including several in more aggressive/innovative categories including oxidation, thermal enhancements (steam, water flood), and others. It is our belief that all categories of remedial technologies were considered, and there is no change in that understanding currently. From this wide set of remedial technologies, four were selected for detailed consideration based on their characteristics relative to site conditions and cleanup goals.

Rather than revisit the CMS in detail, this update will simply point out some of the more relevant details as they applied to the remedy selection decisions. Chapter 7 in the CMS ranked the detailed options according to the following criteria taken from the RCRA Handbook (EPA530-D-00-001, 2001), as listed below:

1. Effectiveness and useful life
2. Reliability and O&M requirements
3. Implementability and constructability
4. Duration
5. Safety
6. Environmental short term and long term
7. Human health short term and long term;
8. Institutional (regulatory and community relations)
9. Cost

While all these factors are important, certain aspects have greater or lesser importance in context with the facility circumstances, the site-specific POC, and other area cleanup goals. In particular, since there are no complete human health risks pathways (Item #7), the safety and constructability of the remedy action becomes paramount (Item #5). Obviously, an unsafe or uncertain action could create a risk where one does not presently exist. Even if safe and effective, if the potential remedy is not constructible, it is eliminated from further consideration. The cost of an action relative to its effectiveness and constructability is also a consideration. If spending additional dollars results in no net benefit or prolongs the path to the beneficial land-use, then those are resources better spent in other areas toward returning this parcel to productive and community-driven uses.

Many of the remedial options considered, including most of those eliminated from detailed consideration, are not adequately safe or constructible in our key areas of concern (Hooven and the Southwest Quad). Six-phase, steam, sparging, vertical soil venting, groundwater circulating wells, in situ oxidation, and others all require high density remedial well spacing (generally less than 50-ft). Those remedial wells would need to be tied to a process grid that includes power, influent/effluent manifolding, and other equipment needs. Given the residences and commercial structures already present in Hooven and the Southwest Quad, none of these potential remedial options is constructible. With respect to other areas within the POC boundary, while some of these options could in principle be used, all would impede the CAP-approved land use plan, with rollouts and cleanup times requiring 10 – 20 years depending on the method (see CMS). Since that land-use plan assures no environmental risk, there would be no-risk benefit to these actions, but there would be community impacts through impeding land-use and delaying the tax revenues gained through those uses.

For the sake of discussion, even if some of these options were theoretically constructible, many present greater health and environmental risk than the no-risk-pathway conditions currently present. For instance, chemical oxidation uses highly exothermic chemicals have inherent dangers and can cause explosive and/or highly exothermic conditions upon their use. Due to hydrogeologic heterogeneity, these chemicals could never be applied with adequate certainty of safe controls beneath widespread buildings and residences. This “cure” may be more dangerous than the “disease.” Similarly, thermal technologies will cause enhanced volatilization and plume mobility in all phases, and without highly certain controls, new risk pathways can be created that do not presently exist. As a site-specific example of this threat, six-phase heating at the Island created new localized observations of dissolved-phase plume emanating from the LNAPL. While in this case there was no risk, this enhanced solubility would be unfavored beneath Hooven or the Southwest Quad. Further, for any of these options, the machinery, controls, heat, energy use, co-pollution, and other operational factors make them unconstructable and/or unsafe in these key areas of concern.

In comparison, the selected remedy is constructible, has “reach” into Hooven and the Southwest Quad, maximizes use of existing infrastructure and remediation footprints, allows the selected land-use in the desired timeframes, and has already been proven safe through past remedial history. In many respects, the selected remedy is a focused, aggressive optimization of past remedial actions that have already proven effective. Pumping under high-grade conditions is expected to maximize recovery, aggressively reduce the residual mobility potential for the LNAPL plume, and enhance biodegradation. The “opening” of the LNAPL smear-zone will allow the HSVE system to more efficiently remove benzene and other volatiles beneath Hooven, causing a coincident decrease in chemical flux and lowering the overall life span of the benzene plume. Recent LNAPL benzene data collected from well MW-96 suggests a concentration in LNAPL that is more than an order of magnitude smaller than was measured in the late 1990s at the same location. This rate of decrease is greater than that observed under ambient conditions and is attributable to the HSVE system operations. In 1999, during the regional drought, the HSVE system experienced large mass recovery increases when the water table fell below the "trigger" elevations. These are direct, site-specific indications that the high-grade remedy has potential to be effective at reaching the specified cleanup goals. While less important than safety, constructability, and effectiveness, the selected remedy also has the greatest cost-benefit. Field pilot-scale testing of the high-grade pumping has recently been completed, and is discussed preliminarily in a following section.

Details of the High-Grade Remedy

As described earlier in this report, the site segment and POC concept was primarily focused on achievement of benzene MCL's at designated locations outside of the plume footprint. A time was also estimated (i.e. 25 to 50 years) that considers the achievement of benzene MCL's throughout the plume based on natural loss mechanisms. The program has these dissolved phase cleanup goals as a primary metric, but also includes additional LNAPL mass recovery (i.e., source removal). The high-grade program is focused on the remaining LNAPL recovery portion of the remedy and objectives associated with its implementation.

The remedy is envisioned to be dynamic and adaptable. Progress toward meeting cleanup goals will be routinely tracked, and the overall appropriateness of the remedy will be revisited every five to ten years. If new technologies have evolved that would result in a better overall solution, the remedy will be revisited.

Background

The Conceptual Remedy Report (CRR) states that, the current program of pumping essentially every day of the year for hydraulic control of the LNAPL and dissolved-phase plumes with LNAPL recovery occurring only during low water positions has reached diminishing returns and is proposed to be replaced with a new program. The new program takes advantage of the natural stability of the plumes (i.e., natural containment) and initiates a seasonally driven recovery program of LNAPL recovery. It also includes a performance-monitoring network that supports the planned changes with maintenance of the plume boundaries and groundwater environmental indicators.

Updated Understanding

The plan for seasonally driven LNAPL recovery is also referred to as the "high-grade" pumping program. As described in the CRR, the sub-areas within the LNAPL plume footprint identified for high-grade actions are based on several factors that indicate that continued LNAPL recovery would further reduce the long term potential for LNAPL mobility and have the highest likelihood for returning potential benefits beneath the village of Hooven and other off-site areas.

The site attributes used for establishing the high-grade recovery program include:

1. Setting groundwater altitude "triggers" that initiate and cease LNAPL recovery actions on a seasonal basis until recovery results indicate diminishing returns have been achieved

2. Using groundwater and LNAPL hydrographs to indicate where remaining measurable LNAPL (in monitoring wells) is persistent much of the year and, as a result, LNAPL has

the greatest potential to remobilize (though nothing indicates remobilization will or does occur)

3. Understanding where higher LNAPL conductivity and lower viscosity also indicate a higher mobility potential

4. Understanding where the LNAPL source zone is thickest and where higher LNAPL saturations and corresponding benzene content exist

5. Placing the facets above in context with our key areas of concern and the timeframes of reaching the cleanup goals

Positive benefits for the areas of the site planned for high-grade pumping potentially includes source reduction by draining the source zone by some percentage of recoverable LNAPL through increased gradient control as the result of focused high-yield pumping. Reducing the LNAPL source directly reduces the timeframe of components in LNAPL, further aided by redistribution and increased groundwater advection through pumping in these new focus areas.

High-Grade Pumping Test Summary

A short-term pilot test of high-grade pumping was conducted in May 2005. Only the groundwater-pumping component of the remedy was tested because water levels were above the LNAPL trigger elevation that would cause initiation of LNAPL recovery and the HSVE component of the remedy. Similarly, there is little LNAPL in wells because of groundwater elevations above the trigger levels and LNAPL recovery was not the focus at this time.

The test was implemented as follows. The groundwater containment system was temporarily shutdown and the system was allowed to equilibrate. Following a short duration step-test, focused high-capacity pumping at a maximum of 3,600 gpm was initiated at production well PW-19. The purpose of the test was to observe the degree to which the new focused pumping achieved drawdown goals in Hooven, and to extend that information to the design of the full high-grade system. Results from the testing have not been finalized, but preliminary indications are that aquifer drawdown was achieved at distal locations in Hooven (MW-94s for example). This is an encouraging result, but will need to be placed into broader context with the full test evaluation that is currently in progress. There are also preliminary indications that drawdown was less than predicted by modeling, but still adequate to achieve the stated goals.

Basis for the High-grade Recovery Program

The plume morphology discussed previously has an integral link to the high-grade actions. An outcome of this setting is that LNAPL “appears” in wells and is recoverable as a function of water table elevations (triggers) and those conditions and responses have changed through time. Field observations have shown that the LNAPL is not observed in monitoring wells when the water table completely submerges the smear zone, and that the water table needs to be lower in order to expose the bottom third of the zone before LNAPL enters the wells. This basic understanding comprises the philosophy of high-grade program and setting water level triggers that exploit the appearance and recoverability of the LNAPL.

This enhanced understanding of the LNAPL distribution in the smear zone has been compared with 20-year hydrograph records to show the site-wide frequency and occurrence of LNAPL in monitoring wells from various areas of the site. The analysis generally shows that, except in the high-grade areas, LNAPL in monitor wells is generally less than 0.2 of a foot thick more than 80% of the time for wells in the smear-zone, with some transient and ephemeral exceptions. In fact, several years may pass between periods when LNAPL is measured at all in some monitoring wells. Appearance of LNAPL during these periods is typically the result of drought conditions and a much lower than normal water table.

This nearly depleted smear zone condition is the result of over 20-years of site LNAPL recovery that has removed over 3.5 million gallons of LNAPL from the smear zone. Site records show that over 80% of the volume recovered occurred during the first 3 to 5 years of operations. Based on these same records, measurable LNAPL in wells now occurs under water table conditions that exist less than 10% of the time, as shown in the hydrograph and LNAPL record for MW-21 (Figure 13). This shows that conditions such as these provide considerable constraint for significant LNAPL recovery from this point forward.

Figure 14 illustrates the depleted smear zone conditions that produce the hydrograph and LNAPL record in Figure 13. The profile shown on Figure 14 is from a subsurface investigative tool that utilizes ultraviolet light and resulting LNAPL fluorescence to detect hydrocarbon. The site location is in the north central portion of the site (within 50 feet of MW-21) and indicates that a smear zone approximately 8 feet thick exists from 23 to 31 feet bgs. Groundwater measurements obtained at MW-21 over 10 years show that LNAPL begins to enter the well when the water table drops to about 28 feet bgs. This occurrence indicates there is about a 3-foot thick smear zone that contains a higher percentage of LNAPL saturation when compared to upper portions of the same smear zone.

Smear zone and LNAPL conditions within the high-grade areas are generally different than those outside of the designated areas. The attributes that define these areas have been discussed in previous sections. In summary, the smear zone in the high-grade areas contains LNAPL above residual saturations over a greater vertical thickness and water table conditions than those shown in Figure 13. An example field observation depicting the occurrence of more frequent LNAPL can be seen on Figure 15 for a well (MW-18) located within the identified high-grade area.

Best Available Technology to Achieve Goals

Given that the majority of recoverable LNAPL remains primarily in the lower portion of the smear zone and that this LNAPL has the highest remaining mobility potential, the focus of the remaining LNAPL recovery is on areas of the site where the smear zone is thicker and where recoverable LNAPL generally exists under a wider variety of water table conditions. Based on this understanding, and incorporating the LNAPL viscosity, proximity to receptors and property reuse priorities, sub areas or high-grade areas were identified for additional LNAPL recovery efforts. These areas of focused recovery are shown on Figure 16.

The high permeability and unique multiphase properties of the site soils and LNAPL allow unusual recovery potential when drawdown reaches into the zones with the highest remaining LNAPL saturation. Because of this, and as evidenced through existing recovery history, high-grade recovery also allows subsurface mobilization of LNAPL at large distances (hundreds to thousands of feet) away from the pumping centers. This provides “reach” into areas where access is restricted (i.e. beneath Hooven and the Southwest Quad) and other technologies could not be applied. In addition, this drawdown below the trigger will open up the LNAPL zone to HSVE, which will be turned on using the same triggers.

It is anticipated that two to three low water table conditions occurring over a period of 6 to 10 years will provide the maximum focused LNAPL recovery opportunities, after which the intermediate program will phase into the final MNA stage of the remedy. Experience and past modeling both suggest that most of the attainable LNAPL drainage to a recovery well will occur during the first seasonal pumping drainage event. What little may additionally be recovered will drain to a recovery well during the subsequent drainage event. The results of this recovery program are expected to leave most wells without any measurable LNAPL much of the year, and less than 0.5 feet in wells where LNAPL may accumulate during short-term drought conditions similar to conditions shown in Figure 14. Under these conditions, the LNAPL is expected to be naturally contained, (i.e. not a threat with respect to mobility), and will not require active management. It is also expected that planned land use is compatible with the high-grade activities and can be integrated with its operation.

Remedy Performance Measures

There are five protectiveness categories shown on Table 1. Four of the categories have specific performance monitoring identified with the goal of maintaining incomplete environmental pathways as the site corrective action program transitions to a more focused stage. The fifth category highlights the planned engineering controls compatible for the site.

A basic pathway analysis was performed for each of the first four categories and an associated monitoring program was developed and proposed. The monitoring program includes collecting appropriate surface, groundwater and vapor samples for chemical analysis, as well as using physical measurements such as monitor wells and laser-induced fluorescence technology.

In general, the POC's were identified in the CMS and CRR's. Additional specificity that captures more recent data collection and understanding (i.e. segment identification) is detailed in earlier sections of this report.

Protecting Hooven and POC Segment A

The first protection category is focused on the continued protection of the residents of Hooven and on ensuring containment along the POC segment A (Figure 11). Based on the location of Hooven, there are two primary pathways for protection monitoring: 1) Subsurface vapor intrusion to homes and/or businesses; 2) Groundwater and LNAPL migration at the edges of the LNAPL and dissolved phase plumes.

Subsurface Vapor Intrusion (Hooven)

Though the 2005 RA has determined that there is not a completed vapor pathway under existing conditions, a vapor-monitoring network in Hooven will be maintained for sampling purposes and sampling will be conducted in accordance with appropriate EPA guidance documents. The performance-monitoring network will consist of vapor locations 93, 96, and 99 and 129 (outside the plume). Discrete sampling depths will be 5 and 10 ft-bgs and then at 10-foot intervals down to the water table at each location. This depth is below the typical basement depth and would provide information about possible vapor intrusion issues.

Sampling locations above the plume footprint will be compared with background samples from areas not directly located over the plume. The frequency of sampling will be annual for the first five years, and then every three years thereafter. If conditions permit, the samples will be collected at a "trigger" water level altitude at or below 463.5 feet for one week and before the HSVE system is turned on. Vapor samples will be analyzed for VOCs identified in the Report titled "Subsurface Investigation Field Activities Report and Human Health Risk Assessment, Chevron Cincinnati Facility, Hooven, OH"(June 30, 2005) using method TO-15 or equivalent. Samples will also be analyzed for fixed gases including oxygen and carbon dioxide by EPA Method 1945 (or equivalent).

Plume Stability Monitoring (POC Segment A)

Monitoring for possible LNAPL and/or dissolved phase plume expansion will be accomplished using designated monitoring wells (LNAPL and dissolved phase) at a decreasing frequency through time under ambient conditions. Initial sampling will be at least two times per year, with proposed frequency reductions dependent on those sampling results and findings. As discussed previously, the plume spreading potential diminishes through time, making time-dependent data less needed in the late stages of plume development.

It is anticipated that the impacted area beneath Hooven will be influenced by high-grade LNAPL recovery activities. As described earlier in this report, operations in this area will be initiated using groundwater altitude "triggers" to start and stop the recovery and HSVE programs. LNAPL recovery metrics will include use of tools such as decline curve analysis, changes in LNAPL transmissivity, a decrease in LNAPL gradients, and the overall decline in the frequency and magnitude of LNAPL occurrence in three to four index monitoring wells.

Protecting the Southwest Quad Area and POC Segment A

A second key protection area for people and businesses is in the southwest quad and along the associated POC Segment A. A prior risk assessment for the southwest quad area indicated there were no unacceptable health risks to businesses, their workers, or patrons. Nevertheless, it was determined that buildings constructed in this area should not be constructed with a basement, and should include a vapor barrier in their foundations to add an extra measure of protection. Chevron is working with developers and property owners to implement appropriate institutional controls in the Southwest Quad.

Plume Stability Monitoring along POC Segment A

Plume stability monitoring will be focused on the established points of compliance network. These include 6 monitoring wells and 4 laser induced fluorescence locations. Monitor wells will also include early warning or "sentry" wells established between the edge of the plume and the POC locations. These wells will serve as indicators that the POC may become impacted unless a contingency is undertaken, or the reason for the impact is limited and will not impact the POC.

Protecting the Great Miami River and POC Segment B

The part of the river between the MW-48 and MW-85 well series has recently been rigorously investigated using monitoring wells, piezometers, soil sampling, and laser-induced fluorescence. Understanding of the smear or source zone along this approximately 1800-linear feet stretch of the river has been improved through these investigations and a focus on potential impacts to the river can be assessed. Protection of the river is a key focus in two primary areas: 1) to prevent sheening from residual LNAPL, and 2) control dissolved phase flux into the river such that it is not detectable at or below allowable Ohio surface water standards.

Erosion Protection of the Riverbank (POC Segment B)

As discussed previously, a work plan that addresses the recent riverbank erosion near MW-85 that cut into residual LNAPL in riverbank soils, was submitted to the agency on June 15, 2005 (3rd Groundwater Assessment Work Plan). This work plan addresses interim measures focused on mitigating impacts to the river and investigative aspects focused on options for long-term management. These options include evaluating the use of a constructed barrier or a reconstructed and engineered riverbank.

Longer term monitoring along the 1800-foot section of the river will be performed at several locations where the altitude of the smear zone intercepts the river. Note that the monitoring plans for this segment of the river may be altered based on the final solution being developed by the end of 2005. Monitoring for potential LNAPL impacts will be based on 2 transects of 3 wells each located perpendicular to the river. The accumulation and thickness of LNAPL will be monitored at these transects for gradients that may become established directionally toward the riverbank. An established gradient towards the river in these designated monitoring wells will result in putting the nearby hydraulic control well into operation.

Dissolved Phase Constituents (POC Segment B)

Longer-term monitoring for dissolved phase constituents along the 1800-foot section of the river will be performed in conjunction with the sheening monitoring (above), and will utilize monitoring wells located at the river bank/ smear zone interface. Frequency of monitoring will be semi-annual for the first three years, and annually thereafter. Analytes tested for will be the BTEX compounds.

Current Ohio surface water standards will be utilized for regulatory compliance purposes. Exceeding the standards will result in putting the nearby hydraulic control well in operation at pumping rates that reverse groundwater gradients away from the river.

Protecting The Groundwater Resource From Further Impacts

This protection category recognizes the site-wide impacts of the LNAPL and dissolved phase plumes and establishes a monitoring network focused on two primary objectives: 1) assuring the plumes are stable under all conditions, and 2) tracking the anticipated decline in plume mass through both high-grade and natural loss mechanisms.

Site-Wide Plume Stability

The following key elements will be the components of verifying LNAPL and dissolved-phase plume stability. Adjustments to the overall performance-monitoring program may be made based on the initial suites of data collected.

1. LNAPL gradient maps will be maintained based on a network wells.
2. LNAPL occurrence tracking in context with trigger levels.
3. Dissolved-phase plume tracking, with a transport-based system of indicators to provide the timing and expectations for plume re-equilibration and stability.
4. Tracking of related MNA parameters to verify ongoing degradation of the dissolved-phase plume.

Hydrocarbon Mass Decline (tracking progress)

The cleanup goal of accelerating the rate of chemical depletion in various locations at the site requires tracking of the hydrocarbon mass decline over time. The following monitoring components will be implemented to provide that tracking mechanism.

1. Remedial system tracking of the mass recovery of LNAPL, dissolved-phase impacts in groundwater, vapor phase recovery, and biodegradation destruction rates.
2. System tracking will be area specific, per POC and internal divisions discussed previously (Figure 11).
3. System tracking will be tied to the trigger events that allow the high-grade actions to occur.

Losses due to natural mechanisms will be tracked annually using subsurface vapor monitoring points at three locations along the longitudinal length of the LNAPL plume from up- to down-gradient. These locations will be in the north end of the plume, the central or core area, and near the down gradient edge.

At the 3 monitoring locations mentioned above, a companion sampling location having at least 2 to 3 discrete vertical intervals will be established to track the corresponding depletion in benzene remaining in the LNAPL smear zone. Since the processes associated with the mass transfer of benzene from the LNAPL to the groundwater are relatively slow, sampling will be conducted at 5-year intervals. A monitor well network consisting of 3 to 5 wells will be located in the dissolved portion of the plume to track aqueous phase depletion through natural attenuation mechanisms.

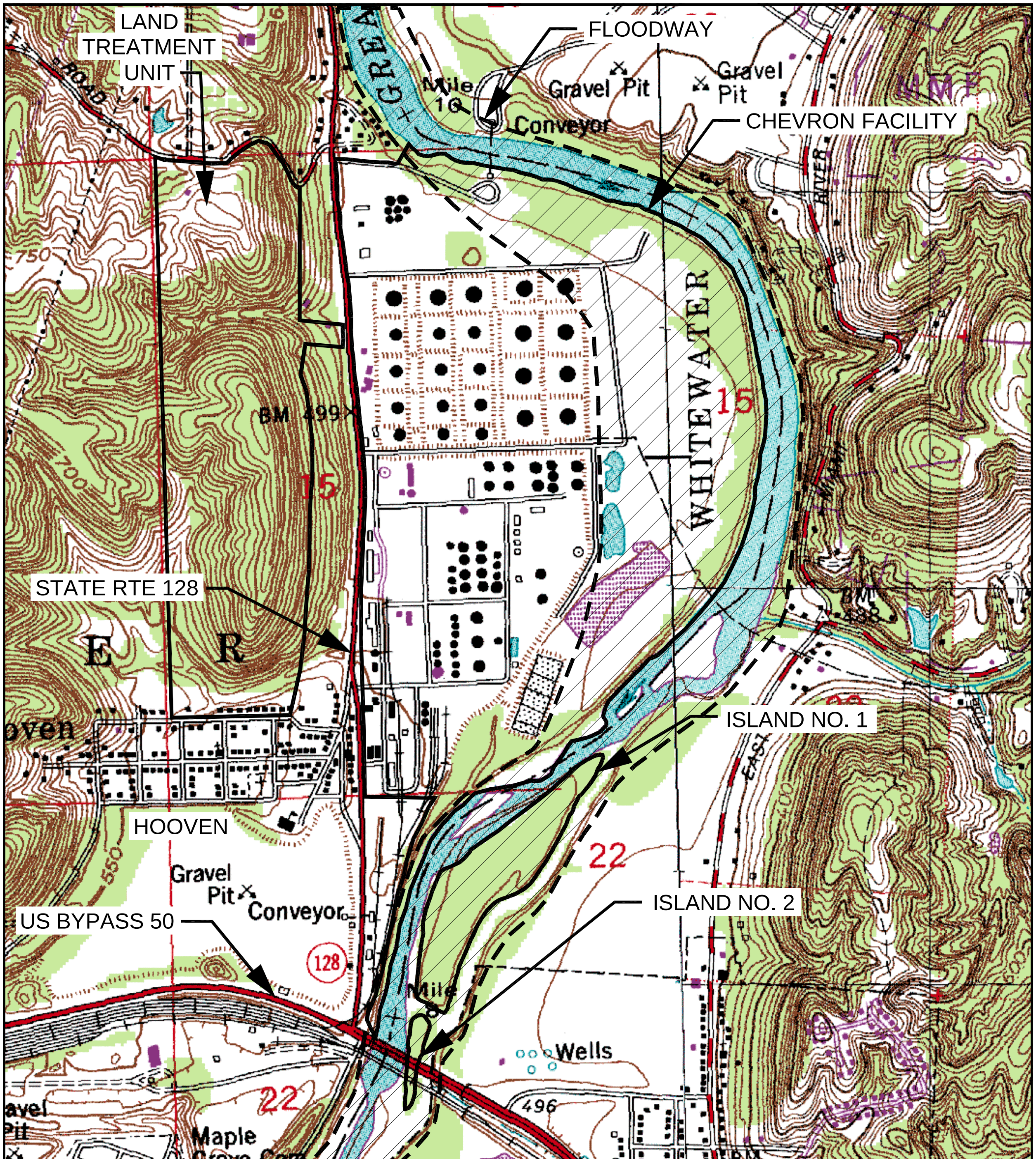
Performance Tracking Summary

These performance monitoring locations and specifics are presented based on the most current information available. They may be updated or revised based on discussions with EPA or through ongoing data evaluation. All in all, the performance monitoring is meant to be a comprehensive discussion of what Chevron's plans are to track progress anticipated as part of the final groundwater remedy. As time goes on and data sets are collected and analyzed, uncertainties that exist now with respect to timeframes and other measures of progress will be minimized. The preliminary evaluations that have led to this final remedy process cannot be further improved with existing data. Consistent with prior discussions, the key necessary updates to site knowledge can only occur through initial implementation of the final remedy process.

Table 1: Overview of Cincinnati Groundwater Remedy

Protectiveness Category	Performance Goal/Standard	Remedy	Monitoring Metric[1]	Contingency[2]
1. Protect People in Hooven	No constituents in vapors > agreed risk-based residential standards	Update human health risk assessment with new data and vapor pathway guidance to confirm no unacceptable risks	OSWER Vapor Intrusion Guidance	Evaluate year-round groundwater pumping, operation of HSVE, and/or other engineered control(s)
	NAPL stability under natural gradient conditions	Monitor to confirm continued plume stability; High-grade NAPL recovery to further reduce potential for NAPL mobility	NAPL non-detect at sentry ROST/ LIF points, no new NAPL occurrence in wells outside smear zone	Resume year-round pumping until compliance with metric is restored; re-evaluate alternate NAPL recovery techniques
2. Protect People in Southwest Quadrant	No constituents in vapors > agreed risk-based industrial/commercial standards	Provide vapor barriers at new businesses	NA	NA
	Restrict groundwater use	Negotiate Institutional Controls	NA	NA
	NAPL stability under natural gradient conditions	Monitor to confirm continued plume stability; High-grade NAPL recovery to further reduce potential for NAPL mobility	NAPL non-detect at sentry ROST/LIF points, no new NAPL occurrence in wells outside smear zone	Resume year-round pumping until compliance with metric is restored; re-evaluate alternate NAPL recovery techniques
3. Protect Great Miami River (GMR)	No NAPL migration or sheen to GMR	Monitored natural attenuation (MNA)	No sheening to river, as measured by oil & grease analysis per OEPA Surface Water Standards	Resume year-round groundwater pumping until compliance with metric is restored and/or evaluate engineered control
	No dissolved constituent flux to River > agreed standards	As above	OEPA Surface Water Standards	As above
4. Protect Groundwater at and Beyond POC	No constituents beyond POC above risk-based standards	MNA, supplemented by high-grade recovery	MCLs at POC	Resume year-round groundwater pumping until compliance with metric is restored
	NAPL stability under natural gradient conditions	Monitor to confirm continued plume stability; High-grade NAPL recovery to further reduce potential for NAPL mobility	NAPL non-detect at sentry ROST/ LIF points, no new NAPL occurrence in wells outside smear zone	Resume year-round pumping until compliance with metric is restored; re-evaluate alternate NAPL recovery techniques
5. Protect On-Site Receptors	No constituents in vapors > agreed risk-based industrial/commercial standards	Implement Engineering Controls with Property Redevelopment	NA	NA
	Prevent exposure to residual impacted soil	Implement Institutional Controls with Property Redevelopment	NA	NA
	Prevent groundwater use	Implement Institutional Controls with Property Redevelopment	NA	NA

1 - Monitoring details such as sampling locations, constituents and frequencies to be defined in a Monitoring Plan at a later date
2 - Range of contingencies, any of which could be undertaken if exceedence is statistically significant



NORTH

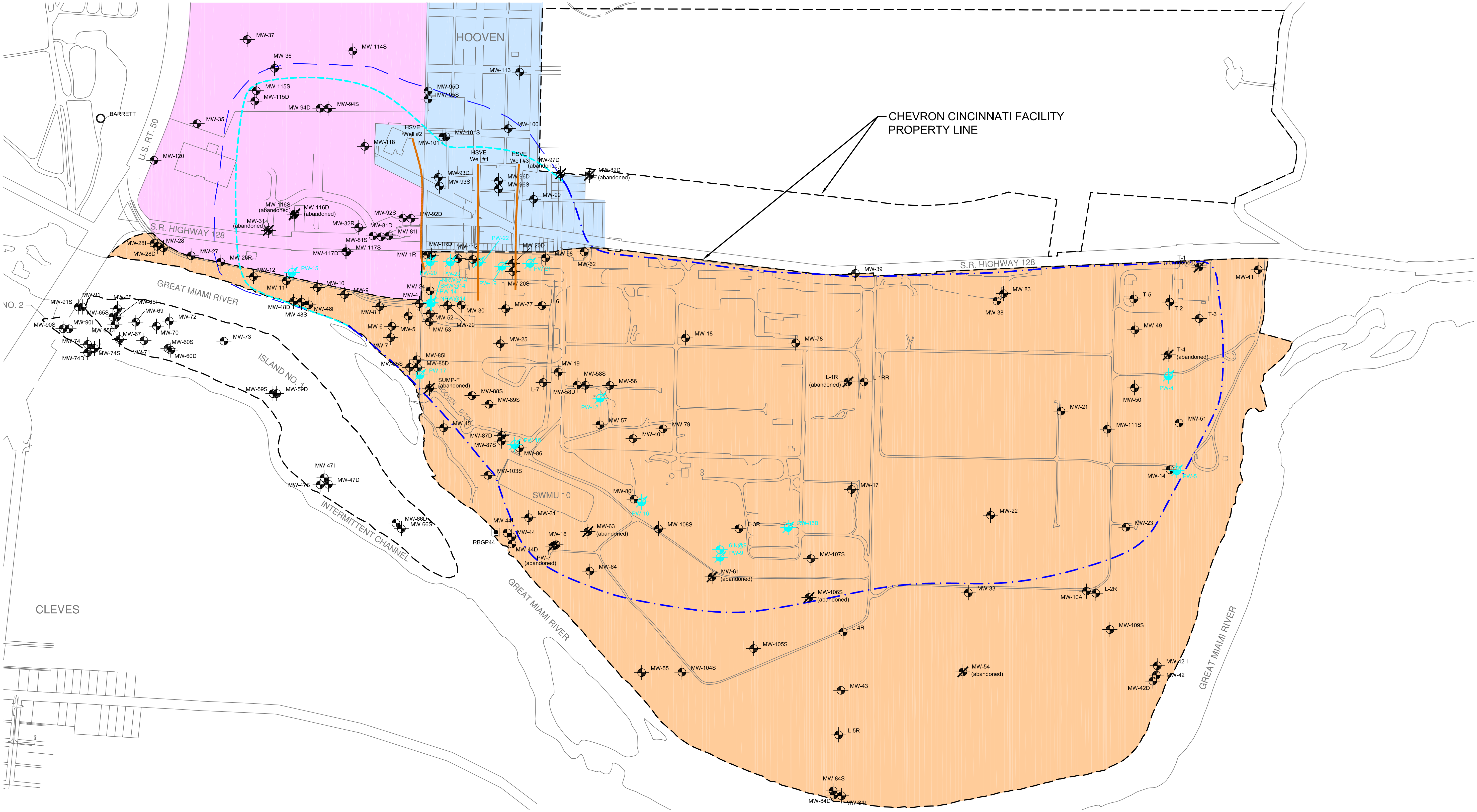
0 400
SCALE : METERS

0 800
SCALE : FEET

URS

Figure 1
Site Location Map and Former Facility Layout
Chevron Cincinnati Facility Site
Most Above-Grade Structures Removed
Hooven, Hamilton County, Ohio

SOURCE: USGS 7.5 MINUTE QUADRANGLE, HOOVEN, OHIO-IND-KY, & ADDYSTON, OHIO-KY, PHOTOREVISED 1987.



LEGEND

MW−75S MONITORING WELL

PW−16 CHEVRON PRODUCTION/ RECOVERY WELL

CHEVRON CINCINNATI FACILITY BOUNDARY

HORIZONTAL SOIL VAPOR EXTRACTION WELL

VILLAGE OF HOOVEN (HOOVEN)

CHEVRON CINCINNATI FACILITY (MAIN SITE)

SOUTHWEST QUADRANT (SWQ)

SCALE: 1"= 600'

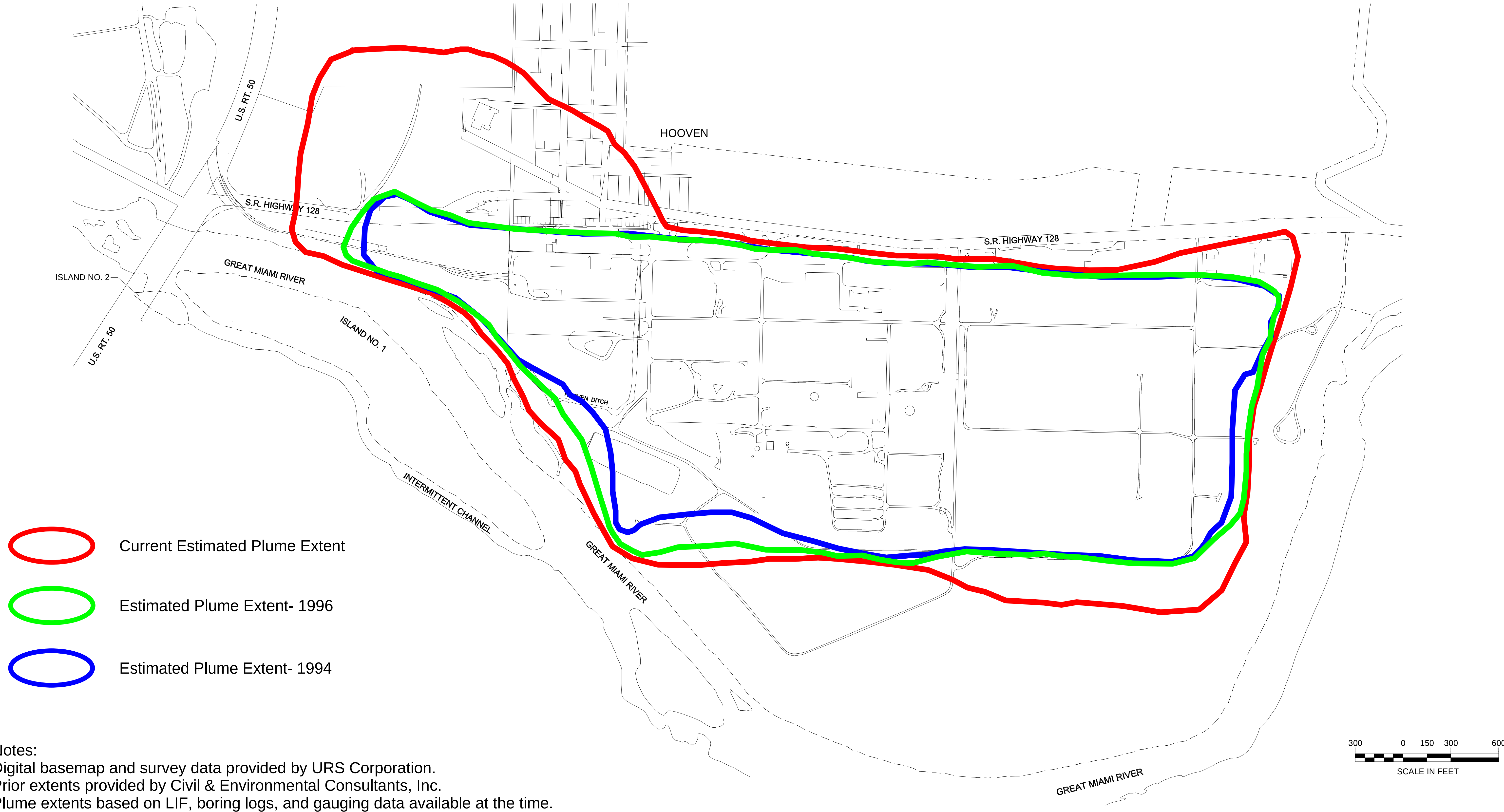
0 600 1200

Facility Diagram
CHEVRON PRODUCTS COMPANY
Cincinnati Facility

Hooven, Hamilton County, Ohio

FIGURE NO:
Figure 2

File: Q:\Chevron Cincinnati Groundwater\Drawings\Containment Options Analysis Reports\2003 04 LNAPL & GW Remedy Report-Int Draft Rev4\gsi002.dwg Layout: FIG 1-2 Plotted: Aug 20, 2003 – 5:34pm



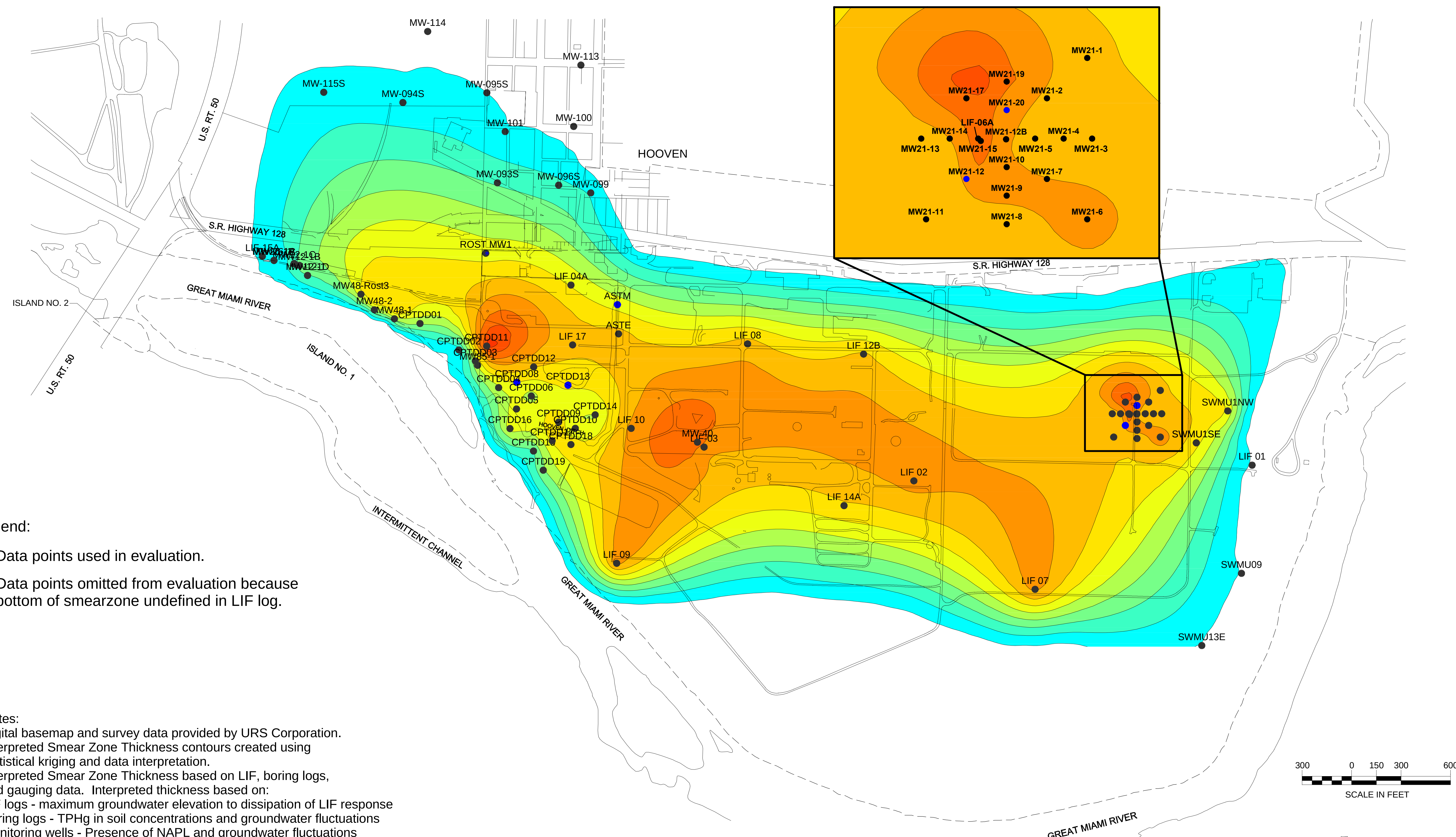
Notes:
Digital basemap and survey data provided by URS Corporation.
Prior extents provided by Civil & Environmental Consultants, Inc.
Plume extents based on LIF, boring logs, and gauging data available at the time.
Changes in plume dimensions from 1996 to current are due to increased data and site knowledge.

AQUI-VER, INC.
Hydrogeology, Water Resources & Data Services

Estimated Plume Extents- Past and Present

Former Chevron Refinery
Cincinnati Facility
Hooven, Hamilton County, Ohio

FIGURE:
3



Legend:

- Data points used in evaluation.
- Data points omitted from evaluation because bottom of smearzone undefined in LIF log.

Notes:
Digital basemap and survey data provided by URS Corporation.
Interpreted Smear Zone Thickness contours created using statistical kriging and data interpretation.
Interpreted Smear Zone Thickness based on LIF, boring logs, and gauging data. Interpreted thickness based on:
LIF logs - maximum groundwater elevation to dissipation of LIF response
Boring logs - TPHg in soil concentrations and groundwater fluctuations
Monitoring wells - Presence of NAPL and groundwater fluctuations

AQUI-VER, INC.
Hydrogeology, Water Resources & Data Services

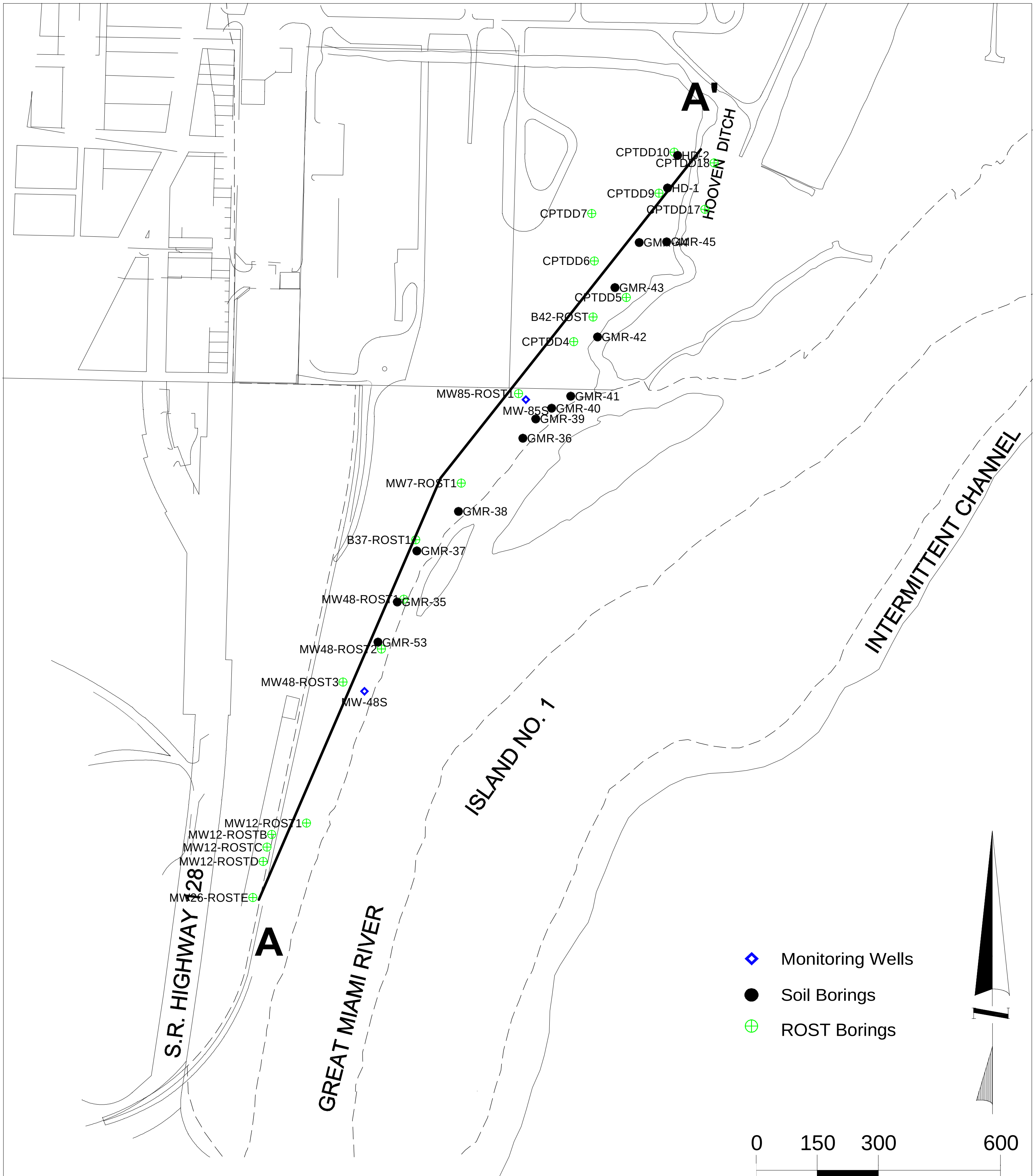
Estimated Smear Zone Thickness (ft)

0 4 8 12 16 20

Interpreted Smear Zone Thickness

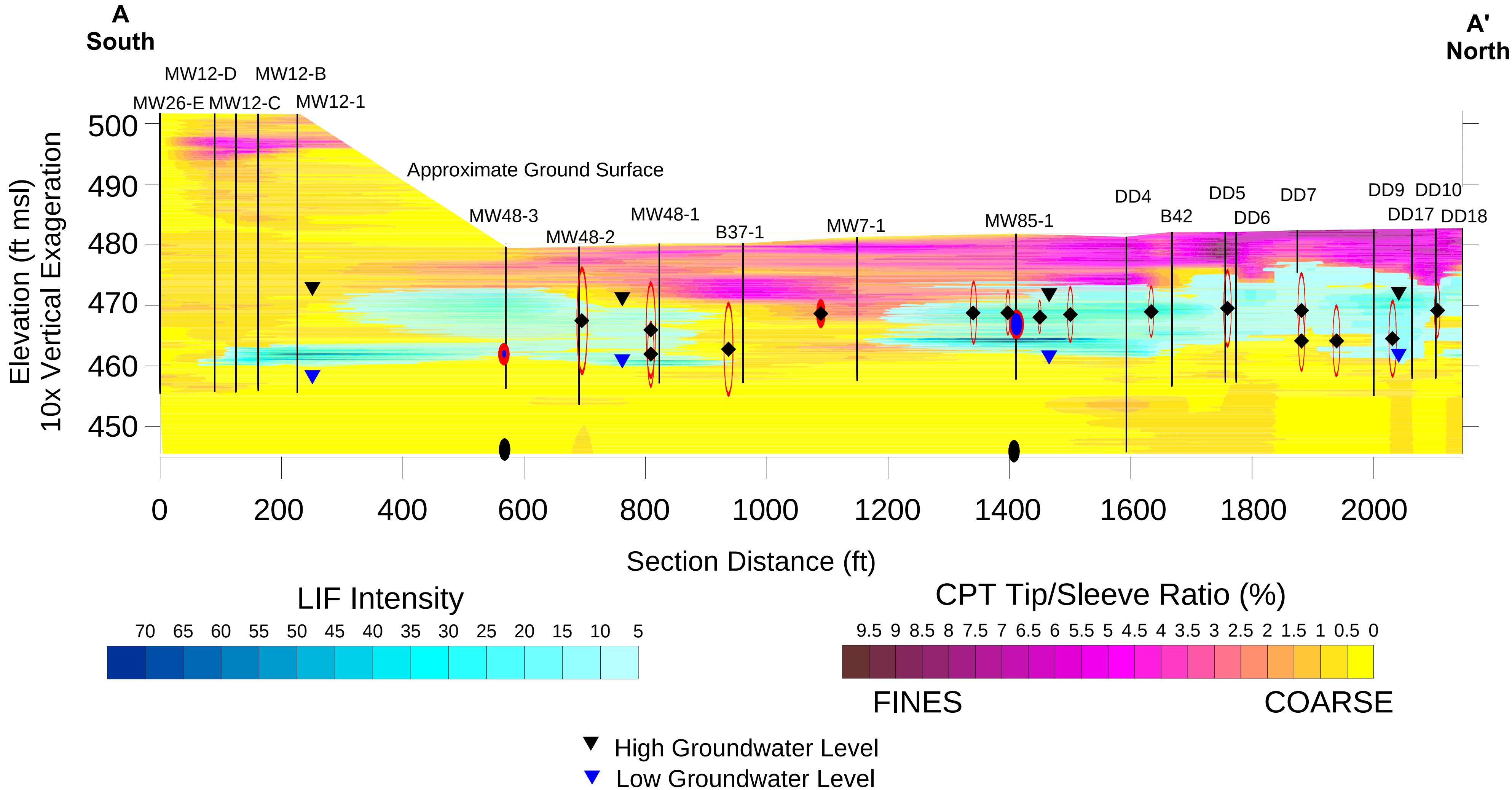
Former Chevron Refinery
Cincinnati Facility
Hooven, Hamilton County, Ohio

FIGURE:
4



Digital basemapprovided by URS Corporation.
Survey data provided by URS Corporation and TriHydro Corp.

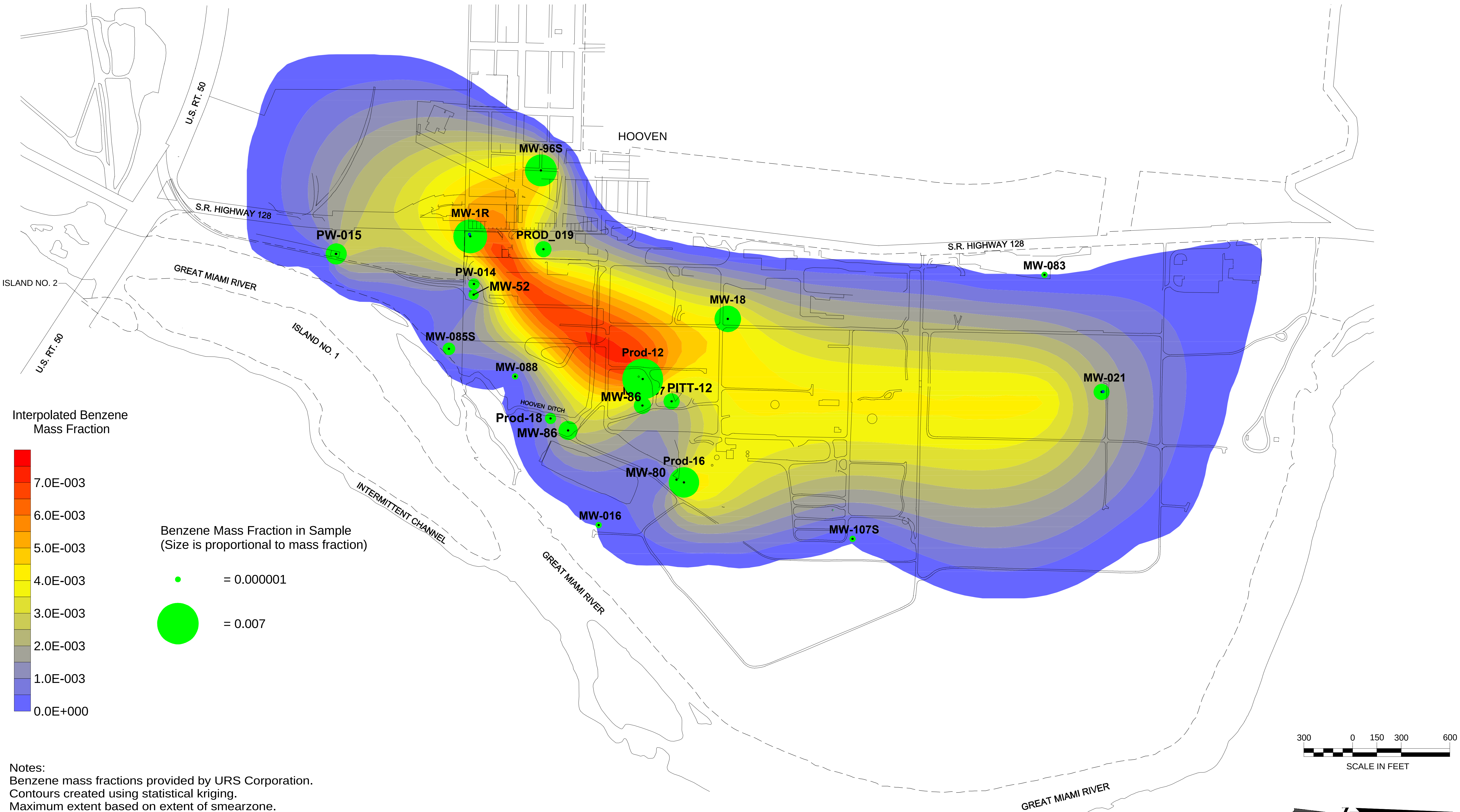
AQUI-VER, INC. *Hydrogeology, Water Resources & Data Services*	**Data Points Collected Along the Great Miami River Bank and Location of Cross-Section A-A'** Former Chevron Refinery Cincinnati Facility Hooven, Hamilton County, Ohio	FIGURE: 5



TPHg in soil (mg/kg) as collected in the fourth quarter 2004 from GMR and HD borings along the cross-section. Symbol is proportional to magnitude of TPHg concentration. Range is 30 to 1700 mg/kg. Solid oval is ND for TPHg. Black diamond is the location of the soil sample. Benzene in soil was nondetect in all soil borings represented here. (From left to right GMR-53, GMR-35, GMR-37, GMR-38, GMR-36, GMR-39, GMR-40, GMR-41, GMR-42, GMR-43, GMR-44, GMR-45, HD-1, and HD-2.)

TPHg and Benzene concentrations in groundwater collected fourth quarter 2004 from MW-48S, MW-48 I, MW-85S and MW-85I. Red oval represents TPHg concentrations and is scaled to concentration, Range is 7.6 to 16 mg/L. Blue oval represents Benzene concentrations and is scaled to concentration, Range is 0.006 to 0.041 mg/L. Black oval represents nondetects for both TPHg and Benzene.

AQUI-VER, INC. *Hydrogeology, Water Resources & Data Services*	**Cross-Section along Banks of Great Miami River showing LIFIntensity and CPT Tip/Sleeve Ration**	Former Chevron Refinery Cincinnati Facility Hooven, Hamilton County, Ohio	FIGURE: 6



Notes:
Benzene mass fractions provided by URS Corporation.
Contours created using statistical kriging.
Maximum extent based on extent of smearzone.
Digital basemap and survey data provided by URS Corporation.

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Interpreted Benzene Mass Fraction Distribution

Former Chevron Refinery
Cincinnati Facility
Hooven, Hamilton County, Ohio

FIGURE:
7

Figure 8: Detailed Geophysical and Analytic Sampling Log

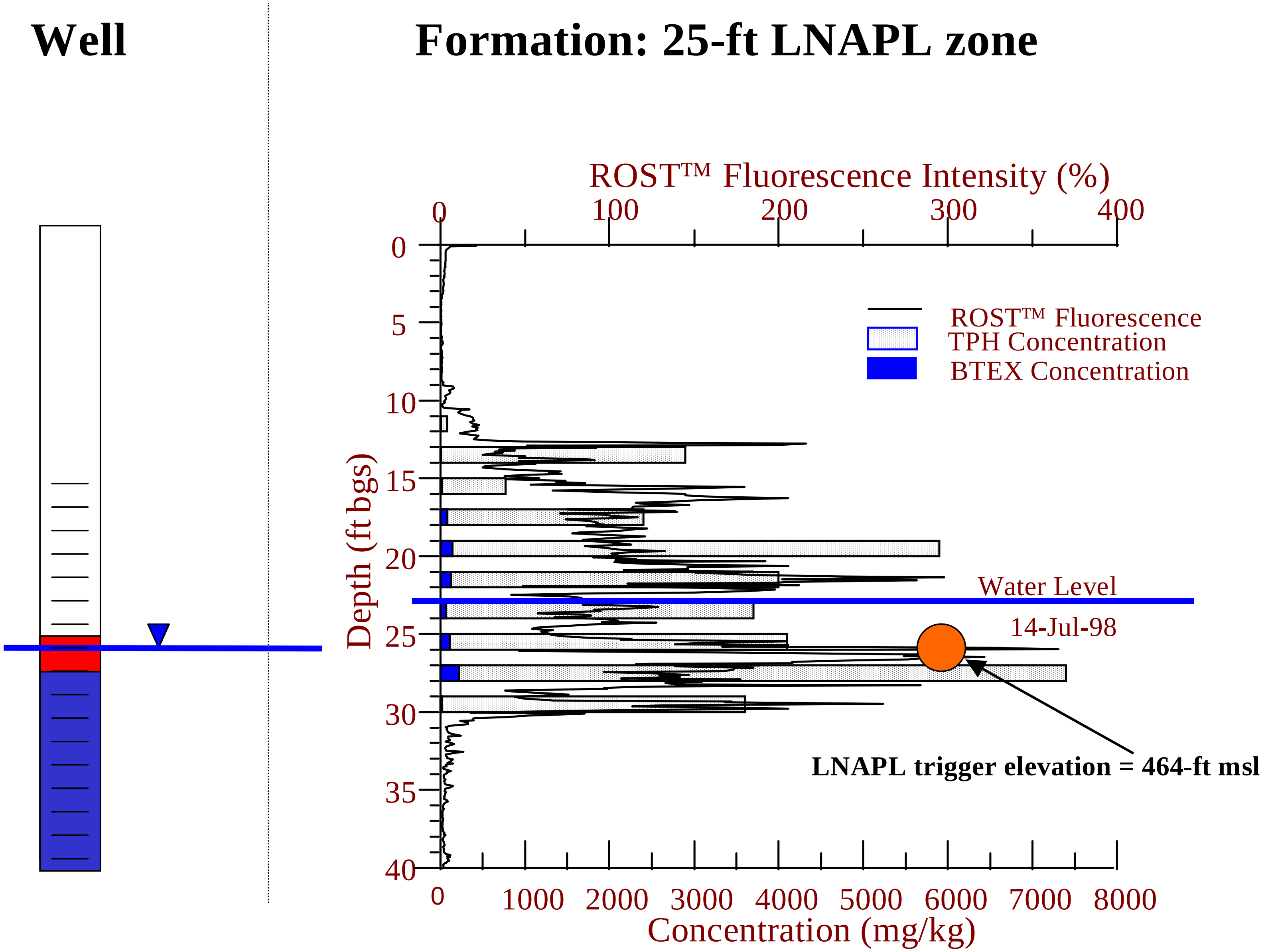
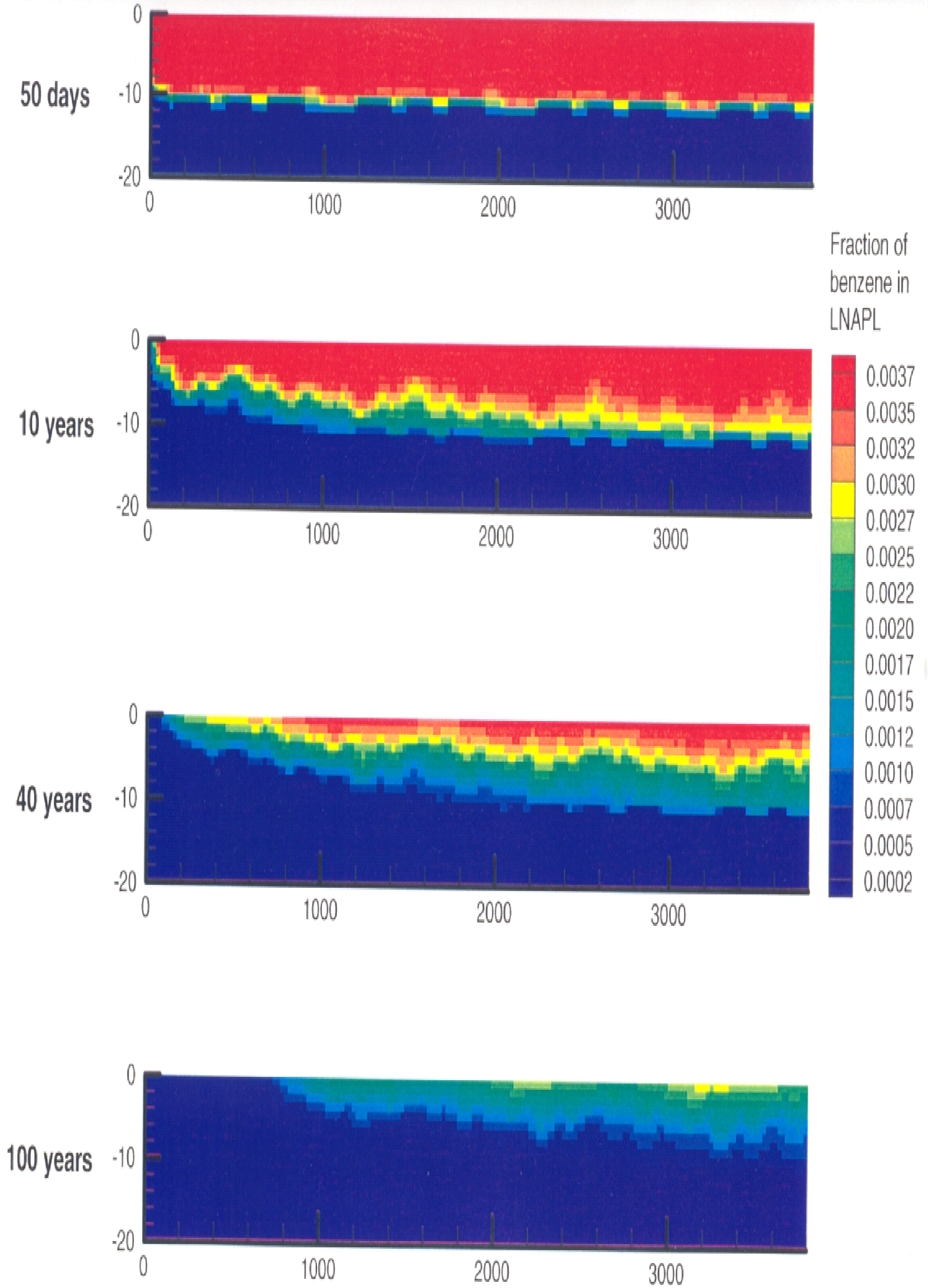
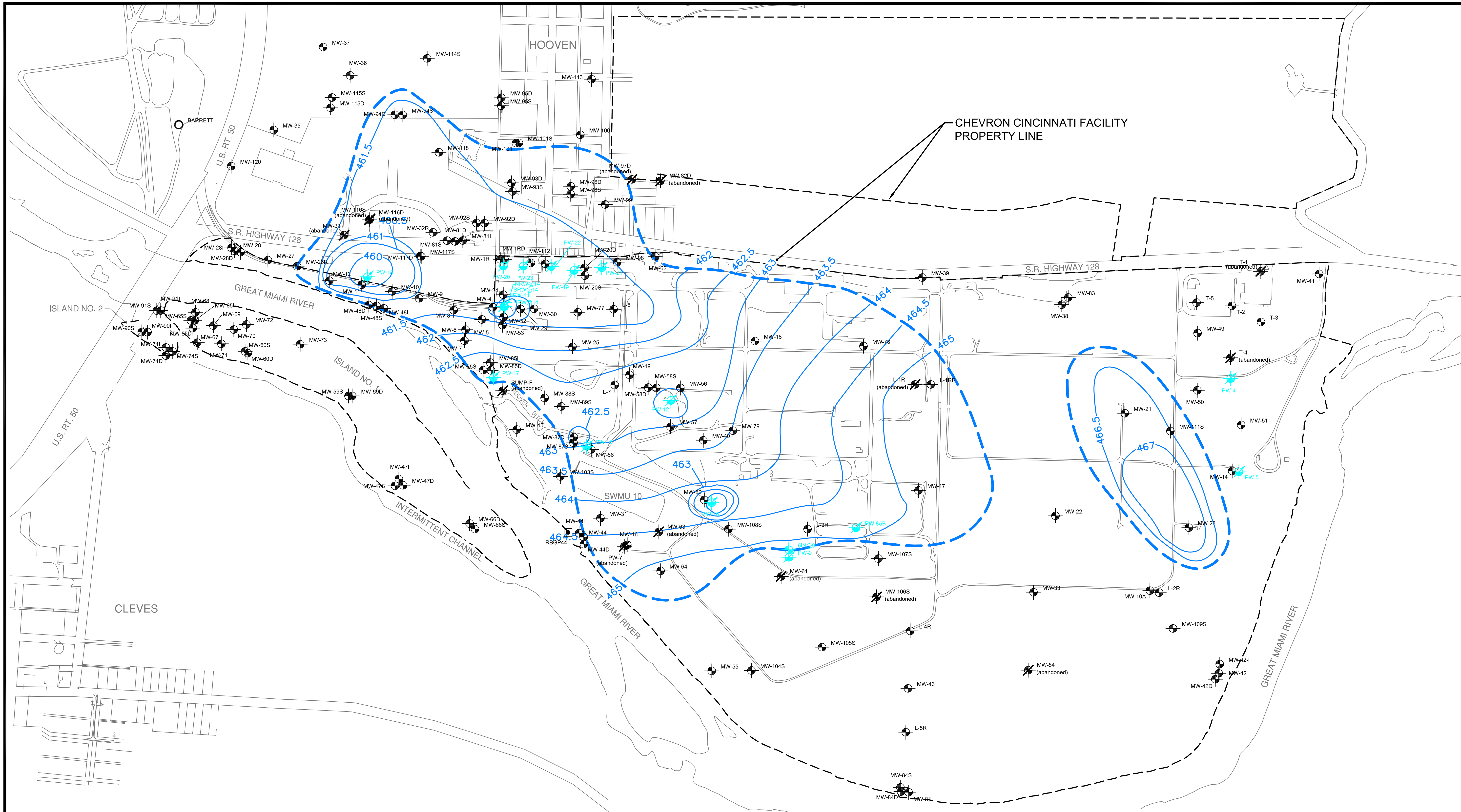


Figure 9: Modeled Dissolved Phase Benzene dissolution (Source: Duke Engineering, in Groundwater CMS, 2001)





LEGEND

MONITORING WELL

CHEVRON PRODUCTION/ RECOVERY WELL

APPROXIMATE EXTENT OF LNAPL

466.5 LNAPL ELEVATION CONTOURS (ft/msl)

SCALE: 1"= 600'

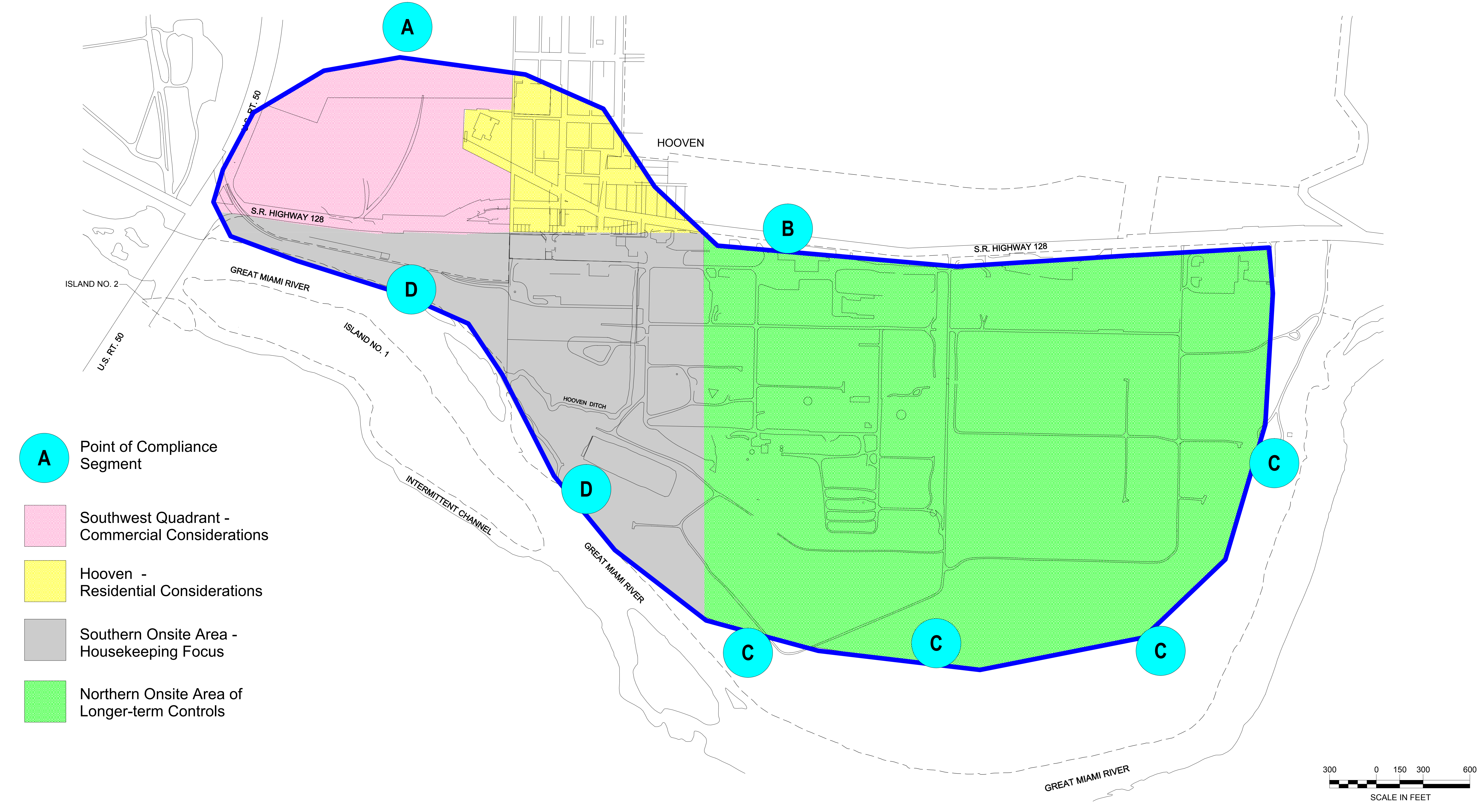
0 600 1200

Top of LNAPL Elevation Map
November 24, 1999

CHEVRON PRODUCTS COMPANY
Cincinnati Facility
Hooven, Hamilton County, Ohio

FIGURE NO:
Figure 10

File: Q:\Chevron Cincinnati Groundwater\Drawings\Containment Options Analysis Reports\2003 04 LNAPL & GW Remedy Report-Int Draft Rev4\LNAPL ELEV 112499.dwg Layout: fig a-15 Plotted: Aug 20, 2003 - 5:41pm



Digital basemap and survey data provided by URS Corporation.

AQUI-VER, INC.

Hydrogeology, Water Resources & Data Services

Point of Compliance Boundary Divided into Key Segments

Former Chevron Refinery
Cincinnati Facility
Hooven, Hamilton County, Ohio

FIGURE:

11

02:000603_CC01_00_11-B0675
Fig1.CDR-9/19/01-GRA

This illustration is included to represent conceptual development of the Chevron site only. It is not intended to propose or endorse a specific layout or development plan.

MIXED USE SCENARIO
based on voting results from 4/2/97 CAP meeting and 5/7/97 CAP meeting.

Plan revisions approved by CAP on 4/4/01.

Prepared: May 28, 1997
Updated: September 2001

Figure 12
REVISED MIXED USE SCENARIO CONCEPTUAL MASTER PLAN, 2001

Chevron

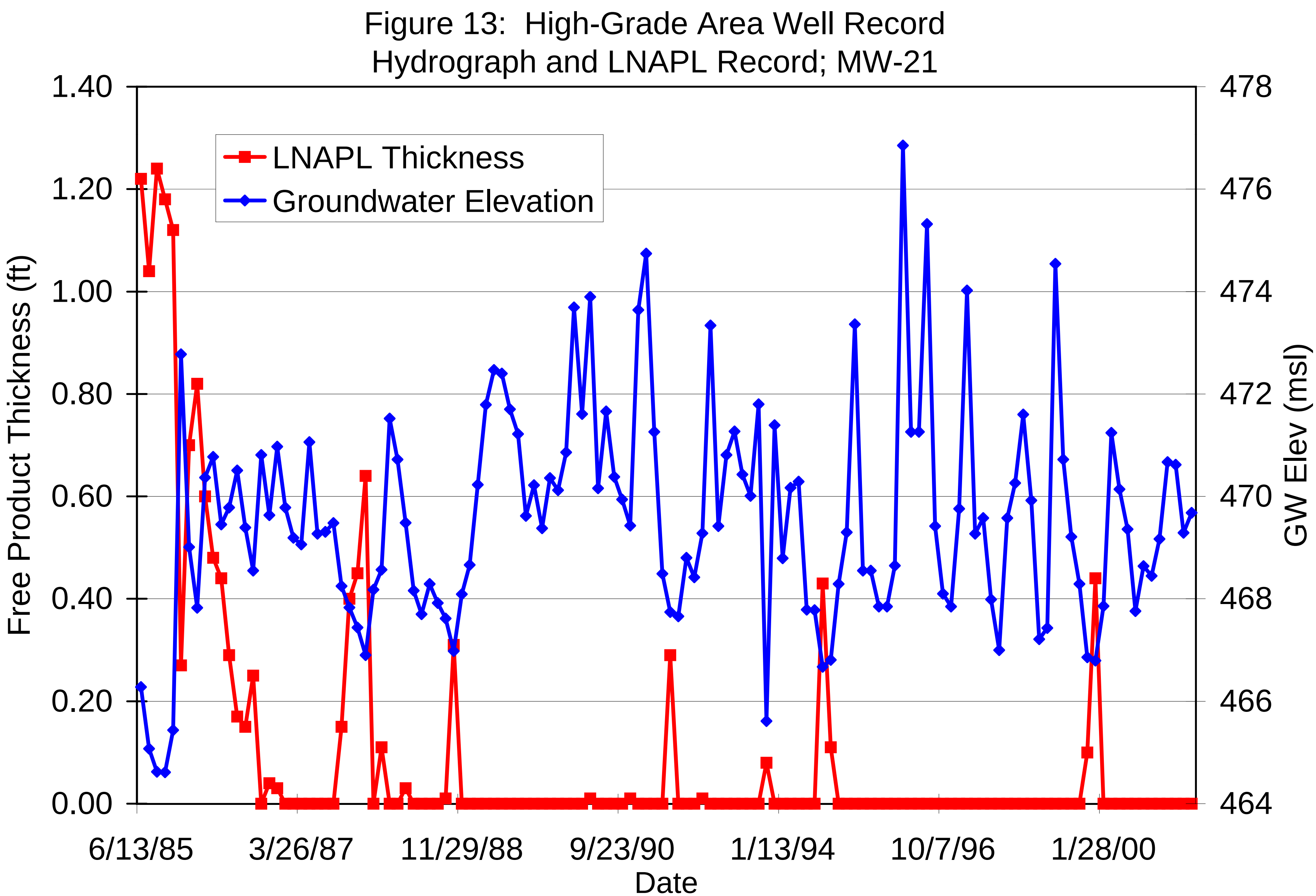
Chevron Cincinnati Facility
Hamilton County, Ohio

SOURCE:

Environmental Science and Engineering; National Wetlands Inventory; Woolpart; Ecology and Environment, Inc.

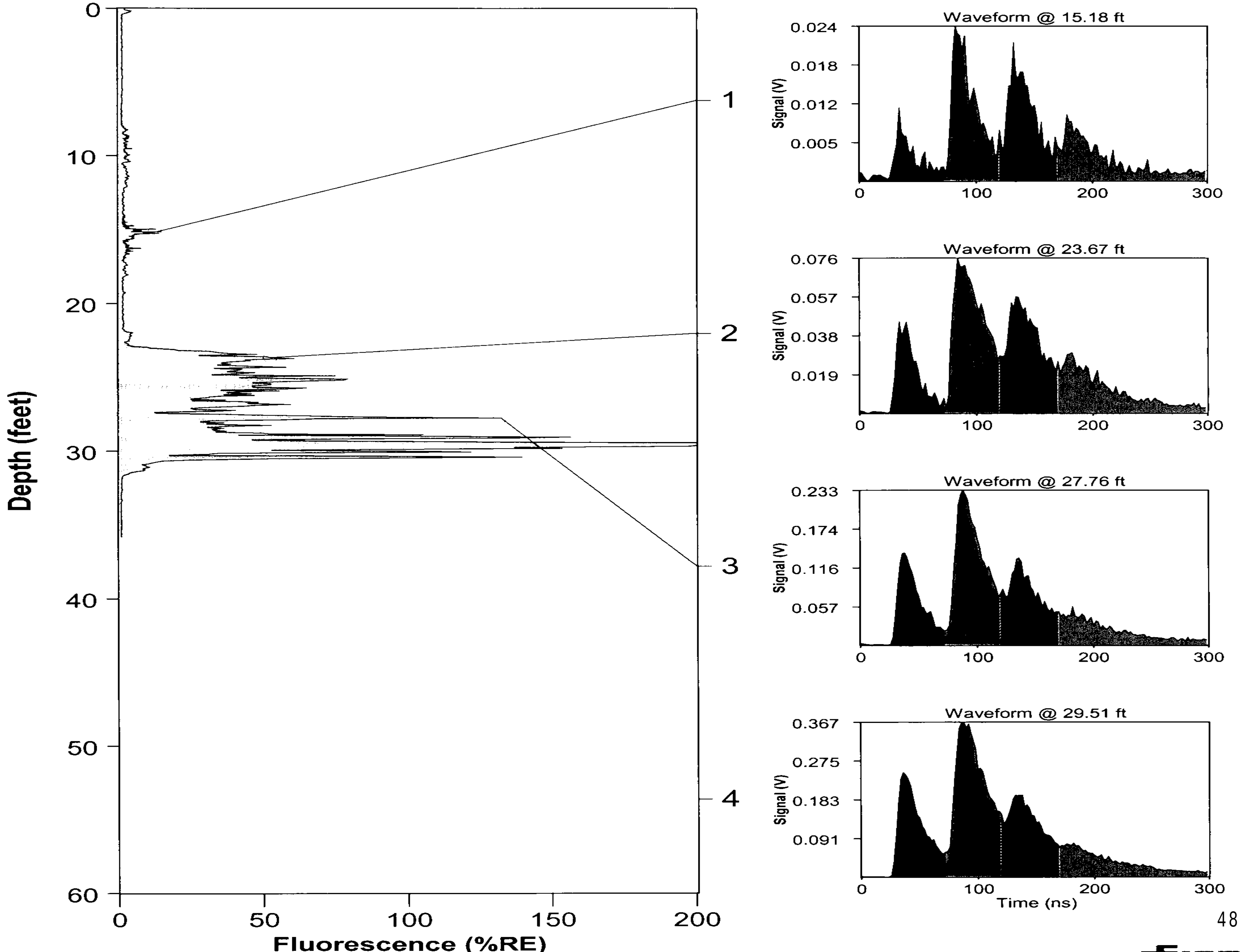
Stateplane Coordinate System
Ohio Southern Zone NAD83

ecology and environment, inc.
International Specialists in the Environment

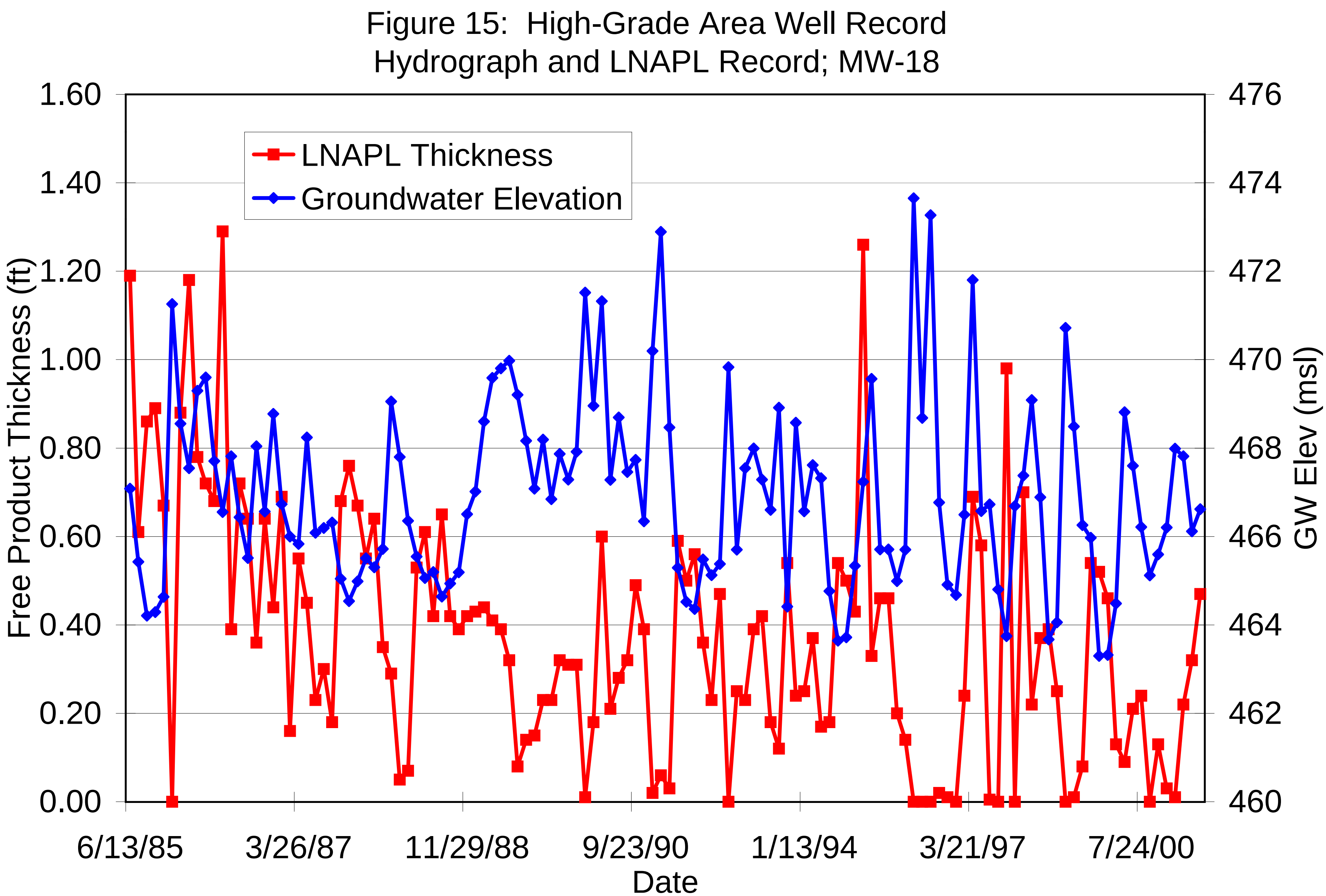


6871 North 2200 West, #8F, Park City, UT Ph. 435 655-8024 Fax 435 655-8026

Figure 14: ROST/LIF Push from North-Central Portion of the Site, Near MW-21



FUGRO



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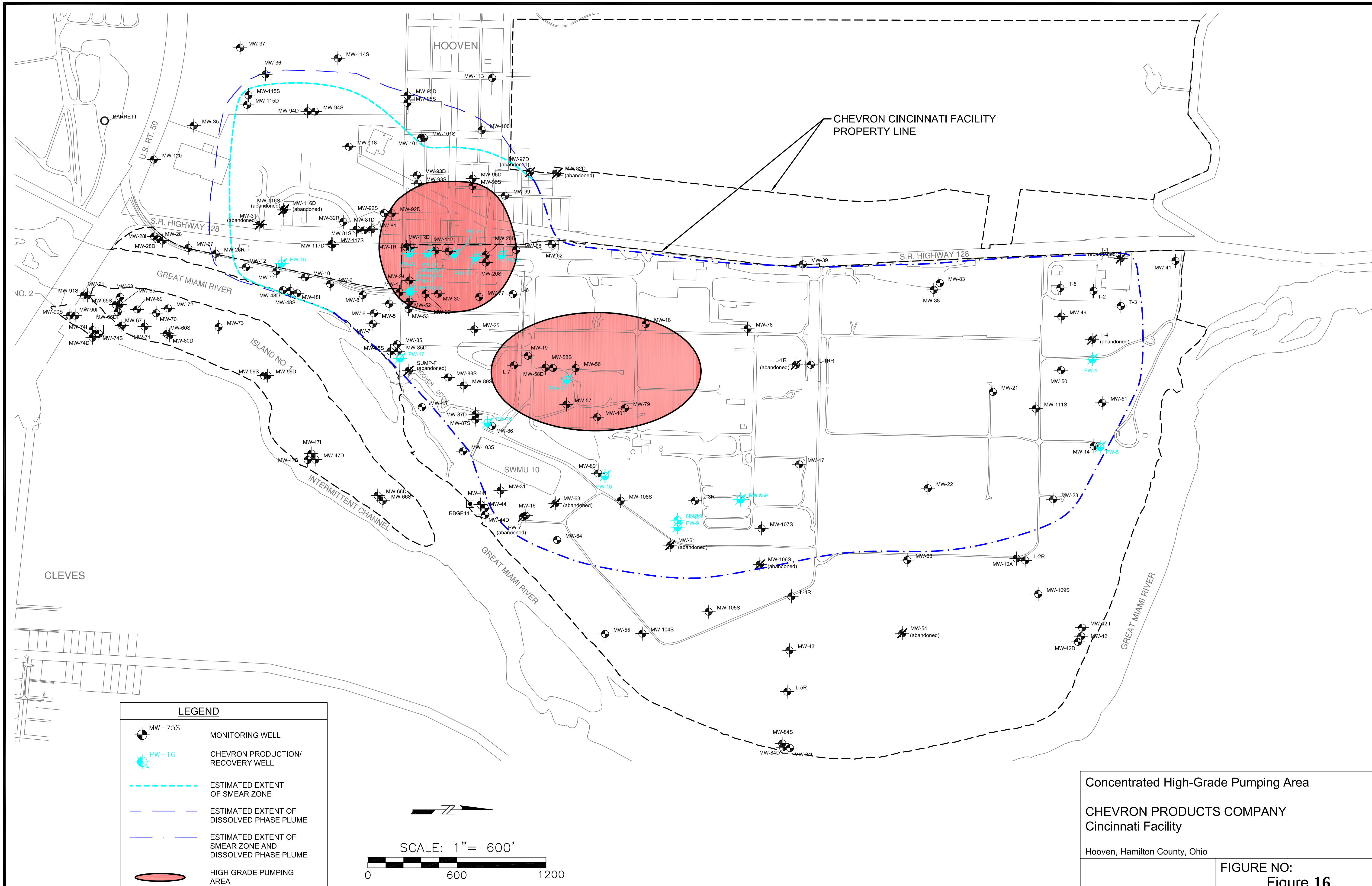
HOOVEN
CHEVRON CINCINNATI FACILITY
PROPERTY LINE
U.S. RT. 50
S.R. HIGHWAY 128
GREAT MIAMI RIVER
ISLAND NO. 2
INTERMITTENT CHANNEL
HOOVEN DITCH
SWMU 10
CLEVES
BARRETT
LEGEND
MW-75S
MONITORING WELL
PW-16
CHEVRON PRODUCTION/
RECOVERY WELL
ESTIMATED EXTENT
OF SMEAR ZONE
ESTIMATED EXTENT OF
DISSOLVED PHASE PLUME
ESTIMATED EXTENT OF
SMEAR ZONE AND
DISSOLVED PHASE PLUME
HIGH GRADE PUMPING
AREA
SCALE: 1"= 600'
0
600
1200
Concentrated High-Grade Pumping Area
CHEVRON PRODUCTS COMPANY
Cincinnati Facility
Hooven, Hamilton County, Ohio
FIGURE NO:
Figure 16